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NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

THE NEW YORK ACADEMY OF SCIENCES.

TRANSACTIONS.

VOL. XXIX.

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1879-80.

NEWCASTLE-UPON-TYNE: A. REID, PRINTING COURT BUILDINGS, AKENSIDE HILL.

1880.

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Report.

NOTWITHSTANDING that during the latter part of the year 1879 there seemed to be some prospect of renewed prosperity in the coal trade, it is much to be regretted that the hopes then entertained were speedily dissipated. It is true that prices have since ruled a fraction higher in the North of England, but even this small increase has not extended into other districts. While this continued depression of the trade, which more particularly interests the Members of the Institute, continues, it is not to be wondered at that the Report, which it is the duty of the Council to present to the Members at their Annual Meeting, should be more or less

ERRATA.

The translation of the Report mentioned on page 112 was placed at the disposition of the Institute by Mr. JAMES ASHWORTH.

On page 159, par. 3, line 9, for "which have been translated by Mr. C. G. Jackson," *read* "which has been translated by the writer with the co-operation of Mr. C. G. Jackson."

and otherwise extend its prestige and standing.

At no time indeed has it been more necessary for gentlemen connected with mining operations to carefully weigh and consider all circumstances tending to cause danger in the working of minerals, and to endeavour by every means in their power to lessen their fatal influences. That accidents are unfortunately in many cases unavoidable is but too true, but that much can be done to lessen their number and diminish their importance is not to be doubted, and nothing can be more conducive to this result than extending our researches into the nature of the circumstances which produce them, and so endeavour to reduce them as much as possible to well ascertained rules.

Although not the chief cause of loss of life, the pressure of gas in coal workings is unquestionably the most alarming from the number of victims it immolates at a time.

To arrive at a more conclusive knowledge of the nature and extent of the phenomena connected with the pressure of gas in coal, our late President, Mr. Lindsay Wood, has been induced to make a series of experiments at some of his collieries, the result of which has been made known in a paper communicated to the members, and which will be published in the next volume.

The Council think that this is the most valuable addition that has been made for some years to our knowledge of the extraordinary power coal possesses of occluding gas at extreme pressures, and there is no doubt that when the records of these experiments have been carefully studied that they will point the way to more effective means of keeping the workings clear.

The experiments that have been made by the Ventilators Committee with a view of ascertaining the relative merits of the various machines employed in producing an artificial current of air in mines by mechanical means may be considered to be of extreme importance, as tending to lessen loss of life from the presence of gas. The results of the experiments will soon be before the public and will afford much valuable information.

With regard to the proceedings generally it may be said that they are above the usual average. Mr. D. P. Morison has summarised all that can be said on the important subject of "Boiler Accidents and their Prevention," and contributed a mass of valuable statistics relating thereto.

The subject of Safety-hooks has also been taken up by Mr. Logan, and most of the inventions for increasing the safety of life in the shafts of pits have been minutely described and commented upon.

Safety-lamps have also been treated in the same way by Mr. A. R. Sawyer and Mr. James Ashworth, the latter gentleman contributing a valuable translation of the Report of the Government Commission in Belgium.

These papers all refer, more or less, to the preservation of life, but economic matters of considerable importance have also been the subject of several interesting contributions.

That by Mr. Henry Aitken, "On the Extraction of Oil and Ammoniacal Liquors from Coking Coal in Ovens," points out a mode by which products hitherto lost may be made of value; and one by Mr. Rathbone, "On a Method of Washing Coal in Germany," shows how the economical value of inferior coal may be considerably increased.

The papers by Mr. John Daglish, "On an Improved Expansion Gear for Winding Engines;" by Mr. Wigham Richardson, "On the Strength of Wrought Iron in Compression;" by Mr. W. J. Bird, "On Condensation in Steam Pipes;" and by Mr. D. P. Morison, "On Coal-dust Explosions," also add considerably to the value of the Transactions.

There have been no excursions during the year, but a very interesting visit was made to the establishment of Messrs. Black, Hawthorn, and Co., at Gateshead, who were kind enough to exhibit the many important engineering works in course of construction by them, and also their tramway locomotive, under steam.

Finance Report.

THE Finance Committee have to report that the receipts from all sources for the past year have been £1,942 11s. 3d., being £196 0s. 7d. less than last year, when they amounted to £2,138 11s. 10d. This falling off has been chiefly due to the difference in the sales of publications, which amounted last year to £166 13s. 9d., and this year only to £53 7s. 9d., making a difference of £113 6s.

The Members' subscriptions amounted to £1,626 10s. as against £1,709 10s., showing a decrease of £83.

The expenditure has been £1,618 14s. 9d. as against £2,080 4s. 10d. last year, the excess of income over expenditure being £323 16s. 6d.

The Institute continues to hold 134 shares in the Institute and Coal Trade Chambers Company, Limited, to the amount of £2,680.

ADVERTISEMENT.

THE Institute is not, as a body, responsible for the facts and opinions advanced in the Papers read, and in the Abstracts of the Conversations which occurred at the Meetings during the Session.

Dr. THE TREASURER IN ACCOUNT

		£	s.	d.
To 695 Original Members, as per List, 1879-80, 10 of which are Life Members, 1 having paid this year		20	0	0
685 at £2 2s.		1,438	10	0
To 18 Ordinary Members, as per List, 1879-80—1 at £2 2s. and 17 at £3 3s.		55	13	0
To 46 Associate Members, as per List, 1879-80, 1 being a Life Member.				
45 at £2 2s.		94	10	0
To 139 Students, as per List. 1879-80, 1 having paid as Member		2	2	0
138 at £1 1s.		144	18	0
To 4 New Ordinary Members, at £3 3s.		12	12	0
To 2 New Associate Members, at £2 2s.		4	4	0
To 11 New Students, at £1 1s.		11	11	0
To 13 Subscribing Collieries		69	6	0
		1,853	6	0
To Arrears, as per last Balance Sheet	£522 18 0			
Deduct—				
Irrecoverable Arrears not inserted in 1879-80 List, (Dead, Resigned, etc.)	165 18 0			
		357	0	0
To Arrears considered irrecoverable, but since paid		14	14	0
		£2,225	0	0

WITH SUBSCRIPTIONS, 1879-80. CR.

	PAID. £ s. d.	UNPAID. £ s. d.
By 543 Original Members paid	1,140 6 0	
By 127 do. unpaid		266 14 0
By 4 do. dead, unpaid		8 8 0
By 1 do. resigned, unpaid		2 2 0
By 10 do. gone, no address		21 0 0
685		
1 do. paid as Life Member	20 0 0	
By 14 Ordinary Members paid, at £3 3s.	44 2 0	
By 3 do. unpaid, at £3 3s.		9 9 0
By 1 do. unpaid, at £2 2s.		2 2 0
18		
By 36 Associate Members paid, at £2 2s.	75 12 0	
By 7 do. unpaid, at £2 2s.		14 14 0
By 2 do. gone, no address, at £2 2s. ...		4 4 0
45		
By 111 Students paid, at £1 1s.	116 11 0	
By 22 do. unpaid, at £1 1s.		23 2 0
By 5 do. gone, no address, at £1 1s.		5 5 0
138		
By 1 do. paid, as Member	2 2 0	
By 4 New Ordinary Members paid, at £3 3s.	12 12 0	
By 2 New Associate Members paid, at £2 2s.	4 4 0	
By 11 New Students paid, at £1 1s.	11 11 0	
By 13 Subscribing Collieries	69 6 0	
	1,496 6 0	357 0 0
By Members' Arrears	100 16 0	227 17 0
By Students' do.	4 4 0	13 13 0
By Collieries' do.	10 10 0	
By Arrears considered irrecoverable, but since paid	14 14 0	
	1,626 10 0	598 10 0
		1,626 10 0

Audited and Certified,

JOHN G. BENSON & Co.,

FELLOWS OF THE INSTITUTE OF CHARTERED ACCOUNTANTS.

Newcastle-upon-Tyne, August 7th, 1880. £2,225 0 0

TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND

Dr. *For the Year ending*

				£	s.	d.
To Balance at Bankers				166	3	5
To Balance in hands of Treasurer				24	12	10
To Bequest of the late R. Stephenson, Esq., invested in Shares of the Institute and Coal Trade Chambers Co., Limited				2,000	0	0
To further Amount invested in Shares of the above Company				680	0	0
				2,870	16	3
To Dividend of 8 per cent. on 134 Shares of £20 each = £2,680				214	8	0
To Rent of College Class Rooms, less Borough Rates				48	5	6
To Subscriptions for 1879-80 from 543 Original Members ...		£1,140	6 0			
Do. do. 1 do. paid, as Life Member		20	0 0			
Do. do. 14 Ordinary Members ...		44	2 0			
Do. do. 36 Associate Members ...		75	12 0			
Do. do. 111 Students		116	11 0			
Do. do. 1 do. paid as Member		2	2 0			
Do. do. 4 New Ordinary Members		12	12 0			
Do. do. 2 New Associate Members		4	4 0			
Do. do. 11 New Students		11	11 0			
To Subscribing Collieries, viz.:—						
Ashington	£2 2 0					
Haswell	4 4 0					
Hetton	10 10 0					
Lambton	10 10 0					
North Hetton	6 6 0					
Londonderry	10 10 0					
Ryhope	4 4 0					
Seghill	2 2 0					
South Hetton and Murton	8 8 0					
Stella	2 2 0					
Throckley	2 2 0					
Wearmouth	4 4 0					
Whitworth	2 2 0					
		69	6 0			
To Members' Arrears	100 16 0					
To Students' do.	4 4 0					
To Collieries' do.	10 10 0					
To Arrears considered irrecoverable, but since paid	14 14 0					
		130	4 0			
				1,626	10	0
To Sale of Publications, per A. Reid		59	6 6			
Less—10 per cent. Commission		5	18 9			
				53	7	9
				£4,813	7	6

INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

August, 1880. Cr.

	£ s. d.	£ s. d.
By Paid A. Reid, Publishing Account	503 13 0	
Do. Covers for Parts and Stitching	10 10 0	
Do. Binding and Sewing Volumes	53 0 0	
Do. Postage	47 5 1	
Do. Stationery and Circulars	83 1 3	
Do. Library	17 7 0	
Do. Borings	54 0 0	
		768 16 4
By other Printing and Stationery		8 2 3
By Secretary's Incidental Expenses and Postage		120 2 6
By Sundry Accounts		54 1 3
By Secretary's Salary		300 0 0
By Assistant's do.		75 0 0
By Reporter's do.		12 12 0
By Payments on account of Furnishing		38 4 8
By Rent		72 17 8
By Rates and Taxes		16 16 3
By Fire Insurance		9 0 6
By Water, Coals, and Gas		17 6 8
By Subscription to the Natural History Society		20 0 0
By Books for Library, in addition to amount paid A. Reid		6 0 0
By Expenses in connection with Ventilator Experiments		58 13 6
By Awards for Papers		41 1 2
		1,618 14 9
By Bequest of the late R. Stephenson, Esq., invested in Shares of the Institute and Coal Trade Chambers Co., Limited	2,000 0 0	
By further Amount invested in Shares of the said Company...	680 0 0	
By Balance at Bankers	469 12 6	
By Balance in hands of Treasurer	45 0 3	
		3,194 12 9
		£4,813 7 6

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GENERAL STATEMENT, AUGUST, 1880.

Dr. Liabilities.	£	s.	d.
None	"	"	"
Capital	7,103	8	3
	£7,103	8	3

Cr. Assets.	£	s.	d.
Balance of Account at Bankers	469	12	6
Balance in hands of Treasurer	45	0	3
134 Shares of £20 each in the Institute and Coal Trade Chambers Company, Limited	2,680	0	0
Arrears of Subscriptions	598	10	0
Value of 358 Bound Volumes of Transactions, @ 11s. 6d.	205	17	0
Value of 3,734 Sewn Copies of Transactions, @ 9s. ...	1,680	6	0
Value of sundry Sheets and Plates belonging to Vol. XXIX., unfinished at this date	150	0	0
Value of 37 Copies of Mr. T. F. Brown's Map of the South Wales Coal-Field, @ 5s.	9	5	0
Value of 485 Copies of General Index, @ 3s.	72	15	0
Value of 821 Copies of Fossil Illustrations, @ 12s. 6d.	513	2	6
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	£7,103	8	3

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THEO. WOOD BUNNING Neville Hall. Newcastle-on-Tyne

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AUGUST, 1880.

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4	ADDY, W. F., Dronfield, near Sheffield	May 6, 1876
5	AITKIN, HENRY, Falkirk, N.B.	Mar. 2, 1865
6	ALLISON, T., Belmont Mines, Guisbro'	Feb. 1, 1868
7	ANDERSON, C. W., Sea View, South Shields	Aug. 21, 1852
8	ANDERSON, WILLIAM, Rainton Colliery, Fence Houses	Aug. 21, 1852
9	ANDREWS, HUGH, Felton Park, Felton, Northumberland	Oct. 5, 1872
10	APPLEBY, C. E., Charing Cross Chambers, Duke Street, Adelphi, London, W.C.	Aug. 1, 1861
11	ARCHER, T., Dunston Engine Works, Gateshead	July 2, 1872
12	ARMSTRONG, SIR W. G., C.B., LL.D., F.R.S., Jesmond, Newcastle-upon-Tyne ... ... (PAST PRESIDENT, *Member of Council*)	May 3, 1866
13	ARMSTRONG, WM., Sen., Pelaw House, Chester-le-Street	Aug. 21, 1852
14	ARMSTRONG, W., Junior, Wingate, Co. Durham *(Member of Council)*	April 7, 1867
15	ARMSTRONG, W. L., Leighs Wood Colliery Co. Ld., Aldridge, nr. Walsall	Mar. 3, 1864
16	ARTHUR, DAVID, M. E., Accrington, near Manchester	Aug. 4, 1877
17	ASHWORTH, JAMES, 56, Upper Duke Street, Southport	Feb. 5, 1876
18	ASHWORTH, JOHN, Bryn Celyn, Llanferis, Mold	Sept. 2, 1876
19	ASQUITH, T. W., Seaton Delaval Colliery, Northumberland	Feb. 2, 1867
20	ATKINSON, J. B., Ridley Mill, Stocksfield-on-Tyne	Mar. 5, 1870
21	ATKINSON, W. N., Shincliffe Hall, Durham	June 6, 1868
22	AUBREY, R. C., Wigan Coal & Iron Co. Ld., Standish, near Wigan ...	Feb. 5, 1870
23	AUSTINE, JOHN, Cadzow Coal Co., Glasgow	Nov. 4, 1876
24	AYNSLEY, WM., Birtley, Chester-le-Street	Mar. 3, 1873
25	BAGLEY, CHAS. JOHN, Tees Bridge Iron Co., Stockton	June 5, 1875
26	BAILES, GEORGE, Murton Colliery, Sunderland	Feb. 3, 1877
27	BAILES, JOHN, Wingate Colliery, Ferryhill	Sept. 5, 1868
28	BAILES, T., Junior, 41, Lovaine Place, Newcastle-on-Tyne	Oct. 7, 1858
29	BAILES, W., Murton Colliery, Sunderland	April 7, 1877
30	BAILEY, G., St. John's Colliery, Wakefield	June 5, 1869
31	BAILEY, SAMUEL, Perry Barr, Birmingham	June 2, 1859

ELECTED.

32 BAIN, R. DONALD, Newport, Monmouthshire ... ... Mar. 3, 1873
33 BAINBRIDGE, E., Nunnery Colliery Offices, Sheffield ... ... Dec. 3, 1863
34 BANKS, THOMAS, Leigh, near Manchester ... ... Aug. 4, 1877
35 BARCLAY, A., Caledonia Foundry, Kilmarnock ... ... Dec. 6, 1866
36 BARKUS, WM., 1, St. Nicholas' Buildings, Newcastle-on-Tyne ... Aug. 21, 1852
37 BARNES, T., Seaton Delaval Office, Quay, Newcastle-on-Tyne ... Oct. 7, 1871
38 BARRAT, A. J., Ruabon Coal Co., Ruabon ... ... Sept. 11, 1875
39 BARTHOLOMEW, C., Castle Hill House, Ealing, London, W. ... ... Aug. 5, 1853
40* BARTHOLOMEW, C. W., Blakesley Hall, near Towcester ... ... Dec. 4, 1875
41 BASSETT, A., Tredegar Mineral Estate Office, Cardiff 1854
42 BATES, MATTHEW, Bews Hill, Blaydon-on-Tyne ... ... Mar. 3, 1873
43 BATES, THOMAS, Heddon, Wylam, Northumberland ... ... Mar. 3, 1873
44 BATES, W. J., Old Axwell, Whickham, Gateshead-on-Tyne ... ... Mar. 3, 1873
45 BATEY, JOHN, Newbury Collieries, Coleford, Bath ... ... Dec. 5, 1868
46 BEANLANDS, A., M.A., North Bailey, Durham ... ... Mar. 7, 1867
47 BEAUMONT, JAMES, M.E., Oughtbridge, near Sheffield ... ... Nov. 7, 1874
48 BELL, I. L., Rounton Grange, Northallerton *(Member of Council)* ... July 6, 1854
49 BELL, JOHN (Messrs. Bell Brothers), Middlesbro'-on-Tees ... ... Oct. 1, 1857
50 BELL, THOMAS, Crosby Court, Northallerton ... ... Sept. 3, 1870
51 BELL, T., Jun. (Messrs. Bell Brothers), Middlesbro'-on-Tees ... ... Mar. 7, 1867
52 BENSON, J. G., Accountant, Newcastle-on-Tyne ... ... Nov. 7, 1874
53 BENSON, T. W., 11, Newgate Street, Newcastle *(Member of Council)* Aug. 2, 1866
54 BERKLEY, C., Marley Hill Colliery, Gateshead ... (VICE-PRESIDENT) Aug. 21, 1852
55 BESWICKE, WM., South Parade, Rochdale ... ... Sept. 11, 1875
56 BEWICK, T. J., M. Inst. C.E., F.G.S., Haydon Bridge, Northumberland (VICE-PRESIDENT) April 5, 1860
57 BIDDER, B. P., c/o C. J. Ryland, 3, Small Street, Bristol ... ... May 2, 1867
58 BIGLAND, J., Bedford Lodge, Bishop Auckland ... ... June 4, 1857
59 BINNS, C., Claycross, Derbyshire ... ... July 6, 1854
60 BIRAM, B., Peaseley Cross Collieries, St. Helen's, Lancashire ... 1856
61 BLACK, JAMES, Jun., Portobello Foundry, Sunderland ... ... Sept. 2, 1871
62 BLACK, W., Hedworth Villa, South Shields ... ... April 2, 1870
63 BOLAM, H. G., Little Ingestre, Stafford ... ... Mar. 6, 1875
64 BOLTON, H. H., Newchurch Collieries, near Manchester ... ... Dec. 5, 1868
65 BOOT, J. T., M.E., Westfield House, Sutton, near Mansfield ... ... April 1, 1871
66 BOOTH, R. L., Ashington Colliery, near Morpeth 1864
67 BORRIES, THEO., Lombard Street, Quay, Newcastle-on-Tyne ... ... April 11, 1874
68 BOURNE, PETER, 39, Rodney Street, Liverpool 1854
69 BOURNE, THOS. W., Broseley, Salop ... ... Sept. 11, 1875
70 BOYD, E. F., Moor House, Fence Houses (PAST PRES., *Mem. of Council*) Aug. 21, 1852
71 BOYD, R. F., Moor House, Fence Houses ... *(Member of Council)* Nov. 6, 1869
72 BOYD, WM., 74, Jesmond Road, Newcastle-on-Tyne ... ... Feb. 2, 1867
73 BRADFORD, GEO., Etherley, Bishop Auckland ... ... Oct. 11, 1873
74 BRECKON, J. R., Park Place, Sunderland ... ... Sept. 3, 1864
75 BRETTELL, T., Mine Agent, Dudley, Worcestershire ... ... Nov. 3, 1866
76 BROGDEN, J. 1861
77 BROMILOW, WM., Queen's Road, Southport, Lancashire ... ... Sept. 2, 1876

ELECTED.

78 BROWN, E., 79, Clayton Street, Newcastle-on-Tyne ... ... Mar. 7, 1874
79 BROWN, JOHN, The Hawthorns, 3, Lozell's Road, Birmingham ... Oct. 5, 1854
80 BROWN, J. N., 56, Union Passage, New Street, Birmingham ... 1861
81 BROWN, THOS. FORSTER, Guild Hall Chambers, Cardiff 1861
82 BROWNE, B. C., Asso. M.I.C.E., No. Granville Road, Jesmond, N'castle Oct. 1, 1870
83 BRUTON, W., Whitwood, Normanton, Streethouse Colls., nr. Normanton Feb. 6, 1869
84 BRYHAM, WILLIAM, Rosebridge Colliery, Wigan ... ... Aug. 1, 1861
85 BRYHAM, W., Jun., Douglas Bank Collieries, Wigan ... ... Aug. 3, 1865
86 BUNNING, THEO. WOOD, Neville Hall, Newcastle-on-Tyne
(Secretary and Treasurer) 1864
87*BURNS, DAVID, C.E., Brookside, Haltwhistle ... ... May 5, 1877
88 BURROWS, JAMES, Douglas Bank, Wigan, Lancashire... ... ... May 2, 1867
89 BURROWS, J. S., Howe Bridge, Atherton, near Manchester ... ... Oct. 11, 1873

90 CALDWELL, GEORGE, Moss Hall Colliery, near Wigan ... ... Mar. 6, 1869
91 CAMPBELL, W. B., Consulting Engineer, Grey Street, Newcastle ... Oct. 7, 1876
92 CARR, WM. COCHRAN, South Benwell, Newcastle-on-Tyne ... ... Dec. 3, 1857
93 CARRINGTON, T., Jun., Endcliffe Court, Sheffield ... ... Aug. 1, 1861
94 CATRON, J., Brotton Hall, Saltburn-by-the-Sea ... ... Nov. 3, 1866
95 CHADBORN, B. T., Pinxton Collieries, Alfreton, Derbyshire 1864
96 CHAMBERS, A. M., Thorncliffe Iron Works, near Sheffield ... ... Mar. 6, 1869
97 CHAPMAN, M., Plashetts Colliery, Northumberland ... ... Aug. 1, 1868
98 CHARLTON, F., C.E., Moot Hall, Newcastle-on-Tyne ... ... Sept. 2, 1871
99 CHARLTON, GEORGE, Washington Colliery, Co. Durham ... ... Feb. 6, 1875
100 CHECKLEY, THOMAS, M.E., Lichfield Street, Walsall ... ... Aug. 7, 1869
101 CHEESMAN, I., Throckley Colliery, Newcastle-on-Tyne ... ... Feb. 1, 1873
102 CHEESMAN, W. T., Wire Rope Manufacturer, Hartlepool ... ... Feb. 5, 1876
103 CHILDE, ROWLAND, Wakefield, Yorkshire ... ... May 15, 1862
104 CLARENCE, THOMAS, Elswick Colliery, Newcastle-on-Tyne ... ... Dec. 4, 1875
105 CLARK, C. F., Garswood Coal and Iron Co., near Wigan ... ... Aug. 2, 1866
106 CLARK, G., Shakespeare Buildings, Hanley, Staffordshire ... ... Dec. 7, 1867
107 CLARK, G., Jun., Southwick Engine Works, Sunderland ... ... Dec. 6, 1873
108 CLARK, R. B., Marley Hill, near Gateshead ... ... May 3, 1873
109 CLARK, W., M.E., The Grange, Teversall, near Mansfield ... ... April 7, 1866
110 CLARKE, WILLIAM, Victoria Engine Works, Gateshead ... ... Dec. 7, 1867
111 COCHRANE, B., Aldin Grange, Durham ... ... Dec. 6, 1866
112 COCHRANE, C., The Grange, Stourbridge ... ... June 3, 1857
113 COCHRANE, W., St. John's Chambers, Grainger Street West, Newcastle
(VICE-PRESIDENT) 1859
114 COCKBURN, G., 8, Summerhill Grove, Newcastle-on-Tyne ... ... Dec. 6, 1866
115 COCKBURN, W., Huntcliffe House, Saltburn-by-the-Sea ... ... Oct. 1, 1859
116 COE, W. S., Newchapel Colliery, Tunstall ... ... Feb. 5, 1876
117 COLE, RICHARD, Walker Colliery, near Newcastle-on-Tyne ... ... April 5, 1873
118 COLE, ROBERT HEATH, Scholar Green, Stoke-upon-Trent ... ... Feb. 5, 1876
119 COLE, W. R., Broomfield, Jesmond, Newcastle-on-Tyne ... ... Oct. 1, 1857
120 COLLIS, W. B., Swinford House, Stourbridge, Worcestershire ... June 6, 1861
121 COOK, J., Jun., Washington Iron Works, Gateshead ... ... May 8, 1869

		ELECTED.
122	COOKE, JOHN, Langley Old Hall, near Durham	Nov. 1, 1860
123	COOKSEY, JOSEPH, West Bromwich, Staffordshire	Aug. 3, 1865
124	COOPER, P., Thornley Colliery Office, Ferryhill...	Dec. 3, 1857
125	COOPER, R. E., C.E., 1, Westminster Chambers, Victoria Street, London	Mar. 4, 1871
126	COOPER, T., Rosehill, Rotherham, Yorkshire	April 2, 1863
127	COPE, JAMES, Port Vale, Longport, Staffordshire	Oct. 5, 1872
128	CORBETT, V. W., Seaton House, Seaham Harbour *(Mem. of Council)*	Sept. 3, 1870
129	CORBITT, M., Wire Rope Manufacturer, Teams, Gateshead	Dec. 4, 1875
130	COULSON, F., 10, Victoria Terrace, Durham	Aug. 1, 1868
131	COULSON, W., 32, Crossgate, Durham	Oct. 1, 1852
132	COWEN, JOS., M.P., Blaydon Burn, Newcastle-on-Tyne	Oct. 5, 1854
133	COWEY, JOHN, Wearmouth Colliery, Sunderland	Nov. 2, 1872
134	COWLISHAW, J., Thorncliffe, &c., Collieries, near Sheffield	Mar. 7. 1867
135	COX, JOHN H., 10, St. George's Square, Sunderland	Feb. 6, 1875
136*	COXE, E. B., Drifton, Jeddo, P. O. Luzerne Co., Penns., U.S. ...	Feb. 1, 1873
137	COXON, HENRY, Quay, Newcastle-on-Tyne	Sept. 2, 1871
138	COXON, S. B., Usworth Colliery, Washington Station, Co. Durham ...	June 5, 1856
139	CRAIG, W. Y., Palace Chambers, St. Stephen's, Westminster, London	Nov. 3, 1866
140	CRAWFORD, T., Littletown Colliery, near Durham	Aug. 21, 1852
141	CRAWFORD, T., 3, Grasmere Street, Gateshead-on-Tyne	Sept. 3, 1864
142	CRAWFORD, T., Jun. Littletown Colliery, near Durham	Aug. 7, 1869
143	CRAWSHAY, E., Gateshead-on-Tyne	Dec. 4, 1869
144	CRAWSHAY, G., Gateshead-on-Tyne	Dec. 4, 1869
145	CROFTON, J, G., Esh Colliery, Durham	Feb. 7, 1861
146	CRONE, E. W., Killingworth Hall, near Newcastle-on-Tyne	Mar. 5, 1870
147	CRONE, J. R., Tow Law, *via* Darlington	Feb. 1, 1868
148	CRONE, S. C., Killingworth Colliery, Newcastle	1853
149	CROSS, JOHN, 78, Cross Street, Manchester	June 5, 1869
150	CROUDACE, C. J., The Laurels, Newton, by Chester	Nov. 2, 1872
151	CROUDACE, JOHN, West House, Haltwhistle	June 7, 1873
152	CROUDACE, THOMAS, Lambton Lodge, New South Wales	1862
153	DAGLISH, JOHN, Marsden, South Shields *(Member of Council)*	Aug. 21, 1852
154	DAGLISH, W. S., Solicitor, Newcastle-on-Tyne	July 2, 1872
155	DAKERS, J., Chilton Colliery, Ferryhill	April 11, 1874
156	DALE, DAVID, West Lodge, Darlington	Feb. 5, 1870
157	D'ANDRIMONT, T., Liége, Belgium	Sept. 3, 1870
158	DANIEL, W., 37, Camp Road, Leeds	June 4, 1870
159	DARLING, FENWICK, South Durham Colliery, Darlington	Nov. 6, 1875
160	DARLINGTON, JOHN, 2, Coleman Street Buildings, Moorgate Street, Great Swan Alley, London	April 1, 1865
161	DARLINGTON, J., Black Park Colliery Co. Limited, Ruabon	Nov. 7, 1874
162	DAVEY, HENRY, C.E., Leeds	Oct. 11, 1873
163	DAVIS, DAVID, Coal Owner, Maesyffynon, Aberdare	Nov. 7, 1874
164	DAY, W. H., Eversley Garth, So. Milford	Mar. 6, 1869
165	DEES, R. R., Solicitor, Newcastle-on-Tyne	Oct. 7, 1871
166	DICKINSON, G. T., 14, Claremont Place, Newcastle-on-Tyne	July 2, 1872

ELECTED.

167 DICKINSON, R., Coal Owner, Shotley Bridge, Co. Durham ... ... Mar. 4, 1871
168 DIXON, D. W., Brotton Mines, Saltburn-by-the-Sea ... ... Nov. 2, 1872
169 DIXON, NICH., Dudley Colliery, Dudley, Northumberland ... ... Sept. 1, 1877
170 DIXON, R., Wire Rope Manufacturer, Teams, Gateshead ... ... June 5, 1875
171 DODD, B., Bearpark Colliery, near Durham ... ... May 3, 1866
172 DODDS, J., M.P., Stockton-on-Tees ... ... Mar. 7, 1874
173 DOUGLAS, C. P., Consett House, Consett, Co. Durham... ... ... Mar. 6, 1869
174 DOUGLAS, T., Pease's West Collieries, Darlington *(Mem. of Council)* Aug. 21, 1852
175 DOUTHWAITE, T., Merthyr Vale Colliery, Merthyr Tydvil ... ... June 5, 1869
176 DOVE, G., Viewfield, Stanwix, Carlisle ... ... July 2, 1872
177 DOWDESWELL, H., Butterknowle Colliery, *via* Darlington ... ... April 5, 1873
178 DYSON, GEORGE, Middlesborough ... ... June 2, 1866
179 DYSON, O. .... Mar. 2, 1872

180 EASTON, J., Nest House, Gateshead 1853
181 ECKERSLEY, NATHANIEL, Standish Hall, Wigan ... ... Sept. 2, 1876
182 EDDISON, ROBERT W., Steam Plough Works, Leeds ... ... Mar. 4, 1876
183 ELAND, J. S., Accountant, Newcastle-on Tyne ... ... Nov. 7, 1874
184 ELLIOT, SIR GEORGE, BART., Houghton Hall, Fence Houses
(PAST PRESIDENT, *Member of Council)* Aug. 21, 1852
185 ELLIOT, W. S., 2, St. George's Terrace, Roker, Sunderland ... ... Sept. 13, 1873
186 ELSDON, ROBERT, 76, Manor Road, Upper New Cross, London ... Nov. 4, 1876
187 EMBLETON, T. W., The Cedars, Methley, Leeds ... ... Sept. 6, 1855
188 EMBLETON, T. W., Jun., The Cedars, Methley, Leeds ... ... Sept. 2, 1865
189 EMINSON, J. B., Londonderry Offices, Seaham Harbour ... ... Mar. 2, 1872
190 EVERARD, I. B., M.E., 6, Millstone Lane, Leicester ... ... Mar. 6, 1869

191 FARMER, A., So. Durham Fitting Offices, West Hartlepool ... ... Mar. 2, 1872
192 FARRAR, JAMES, Old Foundry, Barnsley ... ... July 2, 1872
193 FAVELL, THOMAS M., 14, Saville Street, North Shields ... ... April 5, 1873
194 FEARN, JOHN WILMOT, Chesterfield ... ... Mar. 6, 1869
195 FENWICK, BARNABAS, Team Colliery, Gateshead ... ... Aug. 2, 1866
196 FENWICK, GEORGE, Banker, Newcastle-on-Tyne ... ... Sept. 2, 1871
197 FENWICK, THOMAS, East Pontop Colliery, by Lintz Green ... ... April 5, 1873
198 FERENS, ROBINSON, Oswald Hall, near Durham ... ... April 7, 1877
199 FIDLER, E., Platt Lane Colliery, Wigan, Lancashire ... ... Sept. 1, 1866
200 FISHER, R. C., The Wern, Ystalyfera, Swansea... ... ... July 2, 1872
201 FLETCHER, GEO., Hamsteels Colliery, near Durham ... ... Aug. 1, 1874
202 FLETCHER, H., Ladyshore Coll., Little Lever, Bolton, Lancashire ... Aug. 3, 1865
203 FLETCHER, JAS., Manager Co-operative Collieries, Wallsend, near Newcastle, New South Wales ... ... Sept. 11, 1875
204 FLETCHER, J., Kelton House, Dumfries ... ... July 2, 1872
205 FLETCHER, W., Waterhead, Ambleside ... ... Feb. 4, 1871
206 FOGGIN, WILLIAM, Pensher Colliery, Fence Houses ... ... Mar. 6, 1875
207 FORREST, J., Assoc. Inst. C.E., Pentrehobin Hall, Mold, Flintshire ... Mar. 5, 1870
208 FORSTER, G. B., M.A., Backworth House, near Newcastle-upon-Tyne
(Member of Council) Nov. 5, 1852

		ELECTED.
209	FORSTER, J. R., Water Co.'s Office, Newcastle-on-Tyne	July 2, 1872
210	FORSTER, J. T., Waldridge Colliery, Chester-le-Street	Aug. 1, 1868
211	FORSTER, RICHARD, 51, Quayside, Newcastle-on-Tyne	Oct. 5, 1872
212	FORSTER, R., South Hetton, Fence Houses	Sept. 5, 1868
213	FOSTER, GEORGE, Osmondthorpe Colliery, near Leeds	Mar. 7, 1874
214	FOTHERGILL, J., King Street, Quay, Newcastle-on-Tyne	Aug. 7, 1862
215	FRANCE, FRANCIS, St. Helen's Colliery Co. Ld., St. Helen's, Lancashire	Sept. 1, 1877
216	FRANCE, W., Lofthouse Mines, Saltburn-by-the-Sea	April 6, 1867
217	FRANKS, GEORGE, Victoria Garesfield, Lintz Green	Feb. 6, 1875
218	FRAZIER, PROF. B. W., Lehigh University, Bethlehem, Penns., U.S...	Nov. 2, 1872
219	FURNESS, H. D., Close House, Ravensworth, Gateshead-on-Tyne	Dec. 2, 1871
220	GALLOWAY, R. L., Ryton-on-Tyne	Dec. 6, 1873
221	GALLOWAY, T. LINDSAY, M.A., 28, Enoch Square, Glasgow *(Member of Council)*	Sept. 2, 1876
222	GERRARD, JOHN, Westgate, Wakefield	Mar. 5, 1870
223	GIBSON, JOHN, Ryhope Colliery, near Sunderland	Dec. 4, 1875
224	GILL, HARRY, Consulting Engineer, Newcastle-on-Tyne	May 2, 1874
225	GILLETT, F. C., Midland Road, Derby	July 4, 1861
226	GILMOUR, D., Portland Colliery, Kilmarnock	Feb. 3, 1872
227	GILPIN, EDWIN, 75, Birmingham Street, Halifax, Nova Scotia ...	April 5, 1873
228	GILROY, G., Ince Hall Colliery, Wigan, Lancashire	Aug. 7, 1856
229	GILROY, S. B., M.E., Powell Duffryn Collieries, Aberdare	Sept. 5, 1868
230	GJERS, JOHN, Southfield Villas, Middlesbro'	June 7, 1873
231	GODDARD, F. R., Accountant, Newcastle-on-Tyne	Nov. 7, 1874
232	GOOCH, G. H., Lintz Colliery, Burnopfield, Gateshead...	Oct. 3, 1856
233	GOODMAN, A., Walker Iron Works, Newcastle-on-Tyne	Sept. 5, 1868
234	GORDON, JAMES N., c/o W. Nicolson, 5, Jeffrey's Square, St. Mary Axe, London, E.C.	Nov. 6, 1875
235	GRACE, E. N., Dhadka, Assensole, Bengal, India	Feb. 1, 1868
236	GRANT, J. H., District Engineer, Beerbhoon, Bengal, India	Sept. 4, 1869
237	GREAVES, J. O., M.E., St. John's, Wakefield	Aug. 7, 1862
238	GREEN, J. T., Mining Engineer, Ty Celyn, Abercarn, Newport, Mon.	Dec. 3, 1870
239	GREEN, W., Jun., Thornelly House, Lintz Green *(Member of Council)*	Feb. 4 1853
240	GREENER, JOHN, General Manager, Vale Coll., Pictou, Nova Scotia ...	Feb. 6, 1875
241	GREENER, T., 76, Arlingford Road, Brixton, London, S.W.	Aug. 3, 1865
242	GREENWELL, G. C., Tynemouth ... ... (PRESIDENT)	Aug. 21, 1852
243	GREENWELL, G. C., Jun., Poynton, near Stockport	Mar. 6, 1869
244	GREIG, D., Leeds	Aug. 2, 1866
245	GREY, C. G., 55, Parliament Street, London	May 4, 1872
246	GRIEVES, D., Brancepeth Colliery, Willington, County Durham ...	Nov. 7, 1874
247	GRIFFITH, N. R., Wrexham	1866
248	GRIMSHAW, E. J., 23, Hardshaw Street, St. Helen's, Lancashire ...	Sept. 5, 1868
249	GRIMSHAW, W. J., 1, Caerleon Villas, Prestwich, near Manchester ...	Nov. 1, 1873
250	GROUND, H. N., Ferry Hill, Co. Durham	July 2, 1872
251	GUINOTTE, LUCIEN, Directeur des Charbonnages de Mariemont et de Bascoup, Mons, Belgium	Sept. 2, 1871

		ELECTED.
252	HAGGIE, D. H., Wearmouth Patent Rope Works, Sunderland ...	Mar. 4, 1876
253	HAGGIE, P., Gateshead	1854
254*	HAGUE, ERNEST, Castle Dyke, Sheffield	Mar. 2, 1872
255	HAINES, J. RICHARD, Adderley Green Colliery, near Longton ...	Nov. 7, 1874
256	HALES, C., Nerquis Cottage, Nerquis, near Mold, Flintshire	1865
257	HALL, F. W., 1, Eslington Terrace, Jesmond Road, Newcastle-on-Tyne	Aug. 7, 1869
258	HALL, GEORGE, South Garesfield Colliery, Lintz Green	Mar. 6, 1875
259	HALL, M., Lofthouse Station Collieries, near Wakefield	Sept. 5, 1868
260	HALL, M. S., M.E., Westerton, near Bishop Auckland	Feb. 14, 1874
261	HALL, W., Spring Hill Mines, Cumberland County, Nova Scotia ...	Sept. 13, 1873
262	HALL, WM., Thornley Colliery, County Durham	Dec. 4, 1875
263	HALL, WILLIAM F., Haswell Colliery, Fence Houses	May 13, 1858
264	HANN, EDMUND, New Tredegar Colliery, *via* Cardiff	Sept. 5, 1868
265	HARBOTTLE, W. H., Orrell Colliery, near Wigan	Dec. 4, 1875
266	HARDY, JOS., Preston Colliery, North Shields	June 2, 1877
267	HARGREAVES, WILLIAM, Rothwell Haigh, Leeds	Sept. 5, 1868
268	HARLE, RICHARD, Browney Colliery, Durham	April 7, 1877
269	HARLE, WILLIAM, Pagebank Colliery, near Durham	Oct. 7, 1876
270	HARRISON, R., Eastwood, near Nottingham	1861
271	HARRISON, T., Great Western Colliery, Pontypridd, Glamorganshire	Aug. 2, 1873
272	HARRISON, T. E., C.E., Central Station, Newcastle-on-Tyne	May 6, 1853
273	HARRISON, W. B., Brownhills Collieries, near Walsall	April 6, 1867
274	HASWELL, G. H., 11, South Preston Terrace, North Shields	Mar. 2, 1872
275	HAY, J., Jun., Widdrington Colliery, Acklington	Sept. 4, 1869
276	HECKELS, MATTHEW, Castle Eden Colliery, Co. Durham	April 11, 1874
277	HECKELS, W. J., South Medomsley Colliery, Dipton, by Lintz Green	May 2, 1868
278	HEDLEY, EDW., 2, Church Street, London Road, Derby	Dec. 2, 1858
279	HEDLEY, J. J., Consett Collieries, Leadgate, County Durham ...	April 6, 1872
280	HEDLEY, J. L., Flooker's Brook, Chester	Feb. 5, 1870
281	HEDLEY, T. F., Valuer, Sunderland	Mar. 4, 1871
282	HEDLEY, W. H., Consett Collieries, Medomsley, Newcastle-on-Tyne *(Member of Council)*	1864
283	HENDERSON, H., Pelton Colliery, Chester-le-Street	Feb. 14, 1874
284	HEPPELL, T., Leafield House, Birtley, Fence Houses *(Mem. of Council)*	Aug. 6, 1863
285	HEPPELL, W., Brancepeth Colliery, Willington, County Durham ...	Mar. 2, 1872
286	HERDMAN, J., Park Crescent, Bridgend, Glamorganshire	Oct. 4, 1860
287	HESLOP, C., Lingdale Mines, *via* Guisborough	Feb. 1, 1868
288	HESLOP, GRAINGER, Whitwell Colliery, Sunderland	Oct. 5, 1872
289	HESLOP, J., Hucknall Torkard Colliery, near Nottingham	Feb. 6, 1864
290	HETHERINGTON, D., Coxlodge Colliery, Newcastle-on-Tyne	1859
291*	HEWITT, G. C., Coal Pit Heath Colliery, near Bristol	June 3, 1871
292	HEWLETT, A., Haigh Colliery, Wigan, Lancashire	Mar. 7, 1861
293	HICK, G. W., 14, Blenheim Terrace, Leeds	May 4, 1872
294	HIGSON, JACOB, 94, Cross Street, Manchester	1861
295	HIGSON, P., Crown Chambers, 18, Booth Street, Manchester	Aug. 3, 1865
296	HILL, LESLIE C., Bartholomew House, London, E.C.	Nov. 6, 1875
297	HILTON, J., Standish and Shevington Collieries, near Wigan ...	Dec. 7 1867

ELECTED.

298 HILTON, T. W., Wigan Coal and Iron Co., Limited, Wigan ... ... Aug. 3, 1865
299 HINDMARSH, THOMAS, Cowpen Lodge, Blyth, Northumberland ... Sept. 2, 1876
300 HODGSON, J. W., Dipton Colliery, *via* Lintz Green Station ... ... Feb. 5, 1870
301 HOLLIDAY, MARTIN, M.E., Peases' West Collieries, Crook ... ... May 1, 1875
302 HOLMES, C., Grange Hill, near Bishop Auckland ... ... April 11, 1874
303 HOMER, CHARLES J., Mining Engineer, Stoke-on-Trent ... ... Aug. 3, 1865
304 HOOD, A., 6, Bute Crescent, Cardiff ... ... April 18, 1861
305 HOPE, GEORGE, Newbottle Colliery, Fence Houses ... ... Feb. 3, 1877
306 HORNSBY, H., Whitworth Terrace, *via* Spennymoor, Co. Durham ... Aug. 1, 1874
307 HORSLEY, W., Whitehill Point, Percy Main ... ... Mar. 5, 1857
308 HOSKOLD, H. D., C. and M.E., F.R.G.S., F.G.S., M. Soc. A., &c., Fonda de Oriente, Barcelona, Spain ... ... April 1, 1871
309 HOWARD, W. F., 13, Cavendish Street, Chesterfield ... ... Aug. 1, 1861
310 HUDSON, JAMES, Albion Mines, Pictou, Nova Scotia 1862
311 HUGHES, H. E., Aldridge Colliery, near Walsall, Staffordshire ... Nov. 6, 1869
312 HUMBLE, JOHN, West Pelton, Chester-le-Street ... ... Mar. 4, 1871
313 HUMBLE, JOS., Staveley Works, near Chesterfield ... ... June 2, 1866
314 HUNTER, J., Jun., Silkstone and Worsbro' Park Colls., nr. Barnsley... Mar. 6, 1869
315 HUNTER, W., Monk Bretton Colliery, near Barnsley ... ... Oct. 3, 1861
316 HUNTER, WM., 34, Grey Street, Newcastle ... ... Aug. 21, 1852
317 HUNTER, W. S., Moor Lodge, Newcastle-upon-Tyne ... ... Feb. 1, 1868
318 HUNTING, CHARLES, Fence Houses ... ... Dec. 6, 1866
319 HURST, T. G., F.G.S., Lauder Grange, Corbridge-on-Tyne *(Member of Council)* Aug. 21, 1852

320 JACKSON, C. G., Wigan Coal and Iron Co., Limited, Wigan ... ... June 4, 1870
321 JACKSON, W., Cannock Chase Collieries, Walsall ... ... Feb. 14, 1874
322 JACKSON, W. G., Hazel Farm, Methley, near Leeds ... ... June 7, 1873
323 JARRATT, J., Broomside Colliery Office, Durham ... ... Nov. 2, 1867
324 JEFFCOCK, T. W., 18, Bank Street, Sheffield ... ... Sept. 4, 1869
325 JENKINS, W., M.E., Ocean S.C. Colls., Ystrad, nr. Pontypridd, So. Wales Dec. 6, 1862
326 JENKINS, WM., Consett Iron Works, Consett, Durham ... ... May 2, 1874
327 JOHNASSON, J., Leadenhall Street, London, E.C. ... ... July 2, 1872
328 JOHNSON, HENRY, Dudley, Worcestershire ... ... Aug. 7, 1869
329 JOHNSON, JOHN, M. Inst. C.E., F.G.S., 21, Victoria Square, Newcastle Aug. 21, 1852
330 JOHNSON, J., Witley Colliery Co. Ld., Halesowen, nr. Birmingham Mar. 7, 1874
331 JOHNSON, R. S., Sherburn Hall, Durham ... ... Aug. 21, 1852
332 JOICEY, JOHN, Newton Hall, Stocksfield-on-Tyne ... ... Sept. 3, 1852
333 JOICEY, J. G., Forth Banks West Factory, Newcastle-on-Tyne *(Member of Council)* April 10, 1869
334 JOICEY, W. J., Tanfield Lea Colliery, Burnopfield ... ... Mar. 6, 1869
335 JORDAN, ROBERT, Ebbw Vale, South Wales ... ... Nov. 7, 1874
336 JOSEPH, D. DAVIS, Ty Draw, Pontypridd, South Wales ... ... April 6, 1872
337 JOSEPH, T., Ty Draw, near Pontypridd, South Wales ... ... April 6, 1872

338 KELSEY, W., 41, Fawcett Street, Sunderland ... ... Mar. 7, 1874
339 KENDALL, JOHN D., Roper Street, Whitehaven ... ... Oct. 3, 1874

		ELECTED.
340	KENNEDY, MYLES, M.E., Hill Foot, Ulverstone	June 6, 1868
341	KIMPTON, J. G., 40, St. Mary's Gate, Derby	Oct. 5, 1872
342	KIRKBY, J. W., Ashgrove, Windygates, Fife	Feb. 1, 1873
343	KIRKWOOD, WILLIAM, Larkhall Colliery, Hamilton	Aug. 7, 1869
344	KIRSOPP, JOHN, Team Colliery, Gateshead	April 5, 1873
345	KNOWLES, A., High Bank, Pendlebury, Manchester	Dec. 5, 1856
346	KNOWLES, JOHN, Westwood, Pendlebury, Manchester	Dec. 5, 1856
347	KNOWLES, THOMAS, Ince Hall, Wigan	Aug. 1, 1861
348	KYRKE, R. H. V., Westminster Chambers, Wrexham	Feb. 5, 1870
349	LACKLAND, J. J., Albion Street, Hanley, Staffordshire	Mar. 7, 1874
350	LAIDLER, W. J.	Mar. 4, 1876
351	LAMB, R., Cleator Moor Colliery, near Whitehaven	Sept. 2, 1865
352	LAMB, R. O., Gibside, Lintz Green, Newcastle-on-Tyne	Aug. 2, 1866
353	LAMB, RICHARD W., Coal Owner, Newcastle-on-Tyne...	Nov. 2, 1872
354	LAMBERT, M. W., 9, Queen Street, Newcastle-on-Tyne	July 2, 1872
355	LANCASTER, JOHN, Bilton Grange, Rugby	July 4, 1861
356	LANCASTER, J., Jun., Anfield House, Willes Road, Leamington ...	Mar. 2, 1865
357	LANCASTER, S., Nantyglo & Blaina Steam Coal Collieries, Blaina, Mon.	Aug. 3, 1865
358	LANDALE, A., Lochgelly Iron Works, Fifeshire, N.B.	Dec. 2, 1858
359*	LAPORTE, HENRY, M.E., 80, Rue Royale, Brussels	May 5, 1877
360	LAVERICK, J., 3, Villette Mount, Toward Road, Sunderland	July 2, 1872
361	LAVERICK, ROBT., West Rainton, Fence Houses	Sept. 2, 1876
362	LAWRENCE, HENRY, Grange Iron Works, Durham	Aug. 1, 1868
363	LAWS, H., Grainger Street West, Newcastle-on-Tyne	Feb. 6, 1869
364	LAWS, JOHN, Blyth, Northumberland	1854
365	LAWSON, Rev. E., Longhirst Hall, Morpeth	Dec. 3, 1870
366	LAYCOCK, JOSEPH, Low Gosforth, Northumberland	Sept. 4, 1869
367	LEBOUR, G. A., M.A., F.G.S., College of Physical Science, Newcastle *(Member of Council)*	Feb. 1, 1873
368	LEE, GEORGE, Eston House, Middlesbro'	June 4, 1870
369	LESLIE, ANDREW, Hebburn, Gateshead-on-Tyne	Sept. 7, 1867
370	LEVER, ELLIS, Bowdon, Cheshire	1861
371	LEWIS, HENRY, Annesley Colliery, near Nottingham	Aug. 2, 1866
372	LEWIS, W. H., 3, Bute Crescent, Cardiff	Aug. 4, 1877
373	LEWIS, WILLIAM THOMAS, Mardy, Aberdare	1864
374	LIDDELL, G. H., Somerset House, Whitehaven	Sept. 4, 1869
375	LIDDELL, M., Prudhoe Hall, Prudhoe-on-Tyne	Oct. 1, 1852
376	LINDOP, JAMES, Bloxwich, Walsall, Staffordshire	Aug. 1, 1861
377	LINSLEY, R., Cramlington Colliery, Northumberland	July 2, 1872
378	LINSLEY, S. W., Whitburn Colliery, Sunderland	Sept. 4, 1869
379	LISHMAN, T., Jun., Hetton Colliery, Fence Houses	Nov. 5, 1870
380	LISHMAN, WM., Witton-le-Wear...	1857
381	LISHMAN, WM., Bunker Hill, Fence Houses	Mar. 7, 1861
382	LIVESEY, C., Bredbury Colliery, Bredbury, Stockport	Aug. 3, 1865
383	LIVESEY, T., Bradford Colliery, Manchester	Nov. 7, 1874
384	LLEWELYN, L., Risca Collieries, near Newport, Mon.	May 4, 1872

ELECTED.

385 LOGAN, WILLIAM, Langley Park Colliery, Durham ... ... Sept. 7, 1867
386 LONGBOTHAM, J., Norley Collieries, near Wigan ... ... May 2, 1868
387 LONGRIDGE, J. A., 3, Westminster Chambers, Victoria St., London, S.W. Aug. 21, 1852
388 LOW, W., Vron Colliery, Wrexham, Denbighshire ... ... Sept. 6, 1855
389 LUPTON, A., F.G.S., Crossgates, near Leeds ... ... Nov. 6, 1869

390 MACKENZIE, J., Ashgrove Villa, Ibroxholm, Paisley Road, Glasgow ... Mar. 5, 1870
391 MADDISON, HENRY, The Lindens, Darlington ... ... Nov. 6, 1875
392 MALING, C. T., Ford Pottery, Newcastle-on-Tyne ... ... Oct. 5, 1872
393 MAMMATT, J. E., C.E., St. Andrew's Chambers, Leeds 1864
394 MARLEY, JOHN, Mining Offices, Darlington ... (VICE-PRESIDENT) Aug. 21, 1852
395 MARLEY, J. W., Mining Offices, Darlington ... ... Aug. 1, 1868
396 MARSHALL, F. C., Messrs. Hawthorn & Co., Newcastle ... ... Aug. 2, 1866
397 MARSTON, W. B., Leeswood Vale Oil Works, Mold ... ... Oct. 3, 1868
398 MARTEN, E. B., C.E., Pedmore, near Stourbridge ... ... July 2, 1872
399 MARTIN, R. F., Mount Sorrel, Loughborough ... ... April 11, 1874
400 MATTHEWS, R. F., Seaton Carew, West Hartlepool ... ... Mar. 5, 1857
401 MAUGHAN, J. A., Nerbudda Coal and Iron Co. Limited, Garrawarra, Central Provinces, India ... ... Nov. 7, 1863
402 MAUGHAN, J. D., Hebburn Colliery, near Newcastle-on-Tyne ... Nov. 4, 1876
403 MAY, GEORGE, Harton Colliery Offices, Tyne Docks, South Shields *(Member of Council)* Mar. 6, 1862
404 MCCREATH, J., 95, Bath Street, Glasgow ... ... Mar. 5, 1870
405 MCCULLOCH, DAVID, Beech Grove, Kilmarnock, N.B. ... ... Dec. 4, 1875
406 MCCULLOCH, H. J., Horton House, 277, Camden Road, London, N.... Oct. 1, 1863
407 MCCULLOCH, W., 178, Gresham House, Old Broad Street, London, E.C. Nov. 7, 1874
408 MCGHIE, T., Cannock, Staffordshire ... ... Oct. 1, 1857
409 MCMURTRIE, J., Radstock Colliery, Bath ... ... Nov. 7, 1863
410 MEIK, THOMAS, C.E., 6, York Place, Edinburgh ... ... June 4, 1870
411 MERIVALE, J. H., 2, Victoria Villas, Newcastle ... ... May 5, 1877
412 MILLER, ROBERT, Strafford Collieries, near Barnsley ... ... Mar. 2, 1865
413 MILLS, M. H., Duckmanton Lodge, Chesterfield ... ... Feb. 4, 1871
414 MITCHELL, CHAS., Jesmond, Newcastle-on-Tyne ... ... April 11, 1874
415 MITCHELL, JOSEPH, Worsbro' Dale, near Barnsley .. .. Feb, 14, 1874
416 MITCHINSON, R., Jun., Pontop Coll., Lintz Green Station, Co. Durham Feb. 4, 1865
417 MOFFAT, T., Montreal Iron Ore Works, Whitehaven ... ... Sept. 4, 1869
418 MONKHOUSE, JOS., Yeat House, Frizington, Whitehaven ... ... June 4, 1863
419 MOOR, T., Cambois Colliery, Blyth ... ... Oct. 3, 1868
420 MOOR, WM., Jun., Hetton Colliery, Fence Houses ... ... July 2, 1872
421 MOORE, R. W., Colliery Office, Whitehaven ... ... Nov. 5, 1870
422 MOORE, T. H., Smeaton Park, Inveresk, Edinburgh ... ... Feb. 2, 1867
423 MORISON, D. P., 21, Collingwood St., Newcastle *(Member of Council)* 1861
424 MORRELL, JOHN, Darlington ... ... Oct. 7, 1876
425 MORRIS, W., Waldridge Colliery, Chester-le-Street, Fence Houses ... 1858
426* MORTON, H. J., 4, Royal Crescent, Scarborough 1861
427 MORTON, H. T., Lambton, Fence Houses ... ... Aug. 21, 1852
428 MOSES, WM., Lumley Colliery, Fence Houses ... ... Mar. 2, 1872

ELECTED.

429 MUCKLE, JOHN, Monk Bretton, Barnsley ... ... Mar. 7, 1861
430 MULCASTER, W., Jun., M.E., Croft House, Aspatria, near Carlisle ... Dec. 3, 1870
431 MULVANY, W. T., Pêmpêlfort, Dusseldorf-on-the-Rhine ... ... Dec. 3, 1857
432 MUNDLE, ARTHUR, 7, Collingwood Street, Newcastle-on-Tyne ... June 5, 1875
433 MUNDLE, W., Redesdale Mines, Bellingham ... ... Aug. 2, 1873

434 NANSON, J. ... ... Dec. 4, 1869
435*NASSE, RUDOLPH, Konigl Bergwerks Director, Louisenthal, Saarbrucken, Prussia 1869
436 NAYLOR, J. T., 10, West Clayton Street, Newcastle-on-Tyne ... ... Dec. 6, 1866
437 NELSON, J., C.E., Marine and Stationary Engine Works, Gateshead Oct. 4, 1866
438 NEVIN, JOHN, Mirfield, Yorkshire ... ... May 2, 1868
439 NEWALL, R. S., Ferndene, Gateshead ... ... May 2, 1863
440 NICHOLSON, E., jun., Beamish Colliery, Chester-le-Street ... ... Aug. 7, 1869
441 NICHOLSON, J. W., 36, Crown St., Elswick Road, Newcastle-on-Tyne Oct. 11, 1873
442 NICHOLSON, MARSHALL, Middleton Hall, Leeds ... ... Nov. 7, 1863
443 NOBLE, CAPTAIN, Jesmond, Newcastle-upon-Tyne ... ... Feb. 3, 1866
444 NORTH, F. W., F.G.S., Rowley Hall Colliery, Dudley, Staffordshire ... Oct. 6, 1864
445 NUTTALL, THOMAS, Broad Street, Bury, Lancashire ... ... Sept. 11, 1875

446 OGDEN, JOHN M., Solicitor, Sunderland ... ... Mar. 5, 1857
447 OGILVIE, A. GRAEME, 4, Great George Street, Westminster, London Mar. 3, 1877
448 OLIVER, ROBERT, Charlaw Colliery, near Durham ... ... Nov. 6, 1875

449 PACEY, T., Bishop Auckland ... ... April 10, 1869
450 PALMER, A. S., Wardley Hall, near Newcastle-on-Tyne ... ... July 2, 1872
451 PALMER, C. M., M.P., Quay, Newcastle-upon-Tyne ... ... Nov. 5, 1852
452 PAMELY, C., Radstock Coal Works, near Bath ... ... Sept. 5, 1868
453 PANTON, F. S., Silksworth Colliery, Sunderland ... ... Oct. 5, 1867
454 PARKIN, C., West Haddon Villa, Coatham, Redcar ... ... June 5, 1875
455 PARKIN, JOHN, Westbourne Grove, Redcar, Yorkshire ... ... April 11, 1874
456 PARRINGTON, M. W., Wearmouth Colliery, Sunderland ... ... Dec. 1, 1864
457 PARTON, T., F.G.S., Ash Cottage, Birmingham Road, West Bromwich Oct. 2, 1869
458 PATTISON, JOHN, Engineer, Naples ... ... Nov. 7, 1874
459 PEACE, M. W., Wigan, Lancashire ... ... July 2, 1872
460 PEACOCK, DAVID, West Bromwich ... ... Aug. 7, 1869
461 PEARCE, F. H., Bowling Iron Works, Bradford ... ... Oct. 1, 1857
462 PEASE, J. W., M.P., Hutton Hall, Guisbro', Yorkshire ... ... Mar. 5, 1857
463 PEEL, JOHN, Wharncliffe and Silkstone Coll., Wortley, near Sheffield Nov. 1, 1860
464 PEEL, JOHN, Horsley Colliery, Wylam-on-Tyne ... ... Mar. 3, 1877
465 PEILE, WILLIAM, Rosemount, Roath, Cardiff ... ... Oct. 1, 1863
466 PENMAN, J. H., 2, Clarence Buildings, Booth Street, Manchester ... Mar. 7, 1874
467 PERROT, S. W. ... ... June 2, 1866
468 PHILIPSON, H., 8, Queen Street, Newcastle-upon-Tyne ... ... Oct. 7, 1871
469 PICKUP, P. W., Dunkenhalgh Collieries, Accrington, Lancashire ... Feb. 6, 1875
470 PINCHING, ARCHD. E., The Terrace, Gravesend ... ... May 5, 1877
471 POTTER, ADDISON, Heaton Hall, Newcastle-on-Tyne ... ... Mar. 6, 1869

		ELECTED.
472	POTTER, A. M., Shiremoor Coll., Northumberland *(Member of Council)*	Feb. 3, 1872
473	POTTER, C. J., Heaton Hall, Newcastle-on-Tyne	Oct. 3, 1874
474*	POTTER, W. A., Cramlington House, Northumberland	1853
475	PRICE, JOHN, Messrs. Palmer Brothers & Co., Jarrow-on-Tyne ...	Mar. 3, 1877
476	PRICE, J. R., Standish, near Wigan	Aug. 7, 1869
477	PRIESTMAN, JON., Coal Owner, Newcastle-on-Tyne	Sept. 2, 1871
478	PRINGLE, EDWARD, Choppington Colliery, Northumberland	Aug. 4, 1877
479	RAMSAY, J. A., Westbrook, Darlington	Mar. 6, 1869
480	RAMSAY, J. T., Walbottle Hall, nr. Blaydon-on-Tyne *(Mem. of Council)*	Aug. 3, 1853
481	RAMSAY, T. D.	Mar. 1, 1866
482	RAMSAY, WM., Tursdale Colliery, County Durham	Sept. 11, 1875
483	REED, ROBERT, Felling Colliery, Gateshead	Dec. 3, 1863
484	REES, DANIEL, Glandare, Aberdare	1862
485	REFEEN, WM., Teplitz, Bohemia	Oct. 5, 1872
486	REID, ANDREW, Newcastle-on-Tyne	April 2, 1870
487	RICHARDS, E. W., Messrs. Bolckow, Vaughan, & Co., Middlesbro' ...	Aug. 5, 1876
488	RICHARDS, G. C., M.E., Woodhouse, near Sheffield	June 5, 1875
489	RICHARDSON, H., Backworth Colliery, Newcastle-on-Tyne	Mar. 2, 1865
490	RICHARDSON, J. W., Iron Shipbuilder, Newcastle-on-Tyne	Sept. 3, 1870
491	RIDLEY, G., Trinity Chambers, Newcastle-on-Tyne	Feb. 4, 1865
492	RIDLEY, J. H., R. & W. Hawthorn's, Newcastle-on-Tyne	April 6, 1872
493	RIDYARD, J., Bridgewater Offices, Walkden, nr. Bolton-le-Moors, Lan.	Nov. 7, 1874
494	RIGBY, JOHN, Ash Villa, Alsager, Stoke-upon-Trent	Feb. 5, 1876
495	RITSON, U. A., 6, Queen Street, Newcastle-on-Tyne	Oct. 7, 1871
496	RITSON, W. A., Shilbottle Colliery, near Alnwick	April 2, 1870
497	ROBERTSON, W., M.E., 123, St. Vincent Street, Glasgow	Mar. 5, 1870
498	ROBINSON, G. C., Brereton and Hayes Colls., Rugeley, Staffordshire...	Nov. 5, 1870
499	ROBINSON, H., C.E., 7, Westminster Chambers, London	Sept. 3, 1870
500	ROBINSON, JOHN, Hebburn Colliery, near Newcastle-on-Tyne ...	Nov. 4, 1876
501	ROBINSON, R., Howlish Hall, near Bishop Auckland	Feb. 1, 1868
502	ROBSON, E., Middlesbro'-on-Tees...	April 2, 1870
503	ROBSON, J. S., Butterknowle Colliery, *via* Darlington...	1853
504	ROBSON, J. T., Cambuslang, Glasgow	Sept. 4, 1869
505	ROBSON, THOMAS, Lumley Colliery, Fence Houses	Oct. 4, 1860
506	ROGERSON, John, Croxdale Hall, Durham	Mar. 6, 1869
507	ROSCAMP, J., Rosedale Lodge, near Pickering, Yorkshire	Feb. 2, 1867
508	ROSEBY, JOHN, Haverholme House, Brigg, Lincolnshire	Nov. 2, 1872
509	ROSS, A.	Oct. 1, 1857
510	ROSS, J. A. G., Consulting Engineer, Bath Lane, Newcastle	July 2, 1872
511	ROSSER, W., Mineral Surveyor, Llanelly, Carmarthenshire	1856
512	ROTHWELL, R. P., 27, Park Place, New York	Mar. 5, 1870
513	ROUTLEDGE, JOS., Ryhope Colliery, Sunderland	Sept. 11, 1875
514	ROUTLEDGE, J. L., Ryhope Colliery, Sunderland	Oct. 7, 1876
515	ROUTLEDGE, WM., Sydney, Cape Breton	Aug. 6, 1857
516	ROWLEY, J. C., Shagpoint Colliery, Otago, New Zealand	Dec. 4, 1875
517	RUTHERFORD, J., Halifax, Nova Scotia	1866

		ELECTED.
518	RUTHERFORD, W., Marden House, Whitley, Newcastle-on-Tyne ...	Oct. 3, 1874
519	RUTTER, THOS., Blaydon Main Colliery, Blaydon-on-Tyne	May 1, 1875
520	RYDER, W. J. H., Forth Street Brass Works, Newcastle-on-Tyne ...	Nov. 4, 1876
521	SAINT, GEORGE, Vauxhall Collieries, Ruabon, North Wales	April 11, 1874
522	SCARTH, W. T., Raby Castle, Darlington	April 4, 1868
523	SCOTT, ANDREW, Broomhill Colliery, Acklington	Dec. 7, 1867
524	SCOTT, C. F., Gateshead Fell Colliery, Gateshead-on-Tyne	April 11, 1874
525	SCOULAR, G., Parkside, Frizington, Cumberland	July 2, 1872
526	SEDDON, J. F., Great Harwood Collieries, near Accrington	June 1, 1867
527	SEDDON, W., Dunkirk Collieries, Dukinfield	Oct. 5, 1865
528	SHALLIS, F. W., M. and J. Pritchard, 9, Gracechurch Street, London	April 6, 1872
529	SHAW, JOHN, Neptune Engine Works, Low Walker, Newcastle ...	Nov. 6, 1875
530	SHAW, W., Jun., Wolsingham, *via* Darlington	June 3, 1871
531	SHIEL, JOHN, Framwellgate Colliery, County Durham	May 6, 1871
532	SHONE, ISAAC, Pentrefelin House, Wrexham	1858
533	SHORTREDE, T., Park House, Winstanley, Wigan	April 3, 1856
534	SHUTE, C. A., Westoe, South Shields	April 11, 1874
535	SIMPSON, J., Heworth Colliery, near Gateshead-on-Tyne	Dec. 6, 1866
536	SIMPSON, JOS., Springhill Mines, Cumberland Co., Nova Scotia ...	Mar. 3, 1873
537	SIMPSON, J. B., Hedgefield House, Blaydon-on-Tyne (VICE-PRESIDENT)	Oct. 4, 1860
538	SIMPSON, J. C.	April 7, 1877
539	SIMPSON, R., Moor House, Ryton-on-Tyne	Aug. 21, 1852
540	SIMPSON, ROBT., Drummond Colliery, Westville, Pictou, N.S. ...	Dec. 4, 1875
541	SINCLAIR, JAMES, 48, Blackfriars Street, Manchester	May 6, 1876
542	SLINN, T., 2, Choppington Street, Westmorland Road, Newcastle ...	July 2, 1872
543	SMALL, G., Duffield Road, Derby	June 4, 1870
544	SMITH, G. F., Grovehurst, Tunbridge Wells	Aug. 5, 1853
545	SMITH, J., Bickershaw Colliery, Leigh, near Manchester	Mar. 7, 1874
546*	SMITH, R. CLIFFORD, Parkfield, Swinton, Manchester	Dec. 5, 1874
547	SMITH, T., Sen., M.E., Cinderford Villas, nr. Newnham, Gloucester...	May, 5, 1877
548	SMITH, T. E., M.P., Gosforth House, Dudley, Northumberland ...	Feb. 5, 1870
549	SMITH, T. E., Phœnix Foundry, Newgate Street, Newcastle-on-Tyne	Dec. 5, 1874
550	SNOWDON, T., Jun., West Bitchburn Coll., nr. Towlaw, *via* Darlington	Sept. 4, 1869
551	SOPWITH, A., Cannock Chase Collieries, near Walsall	Aug. 1, 1868
552	SOPWITH, THOS., 6, Great George St., Westminster, London, S.W. ...	Mar. 3, 1877
553	SOUTHERN, R., Burleigh House, The Parade, Tredegarville, Cardiff ...	Aug. 3, 1865
554	SOUTHWORTH, THOS., Hindley Green Collieries, near Wigan	May 2, 1874
555	SPARK, H. K., Startforth House, Barnard Castle	1856
556	SPENCE, G.	June 7, 1873
557	SPENCE, JAMES, Clifton and Millgramfitz Collieries, Workington ...	Nov. 7, 1874
558	SPENCER, JOHN, Westgate Road, Newcastle-on-Tyne	Sept. 4, 1869
559	SPENCER, M., Newburn, near Newcastle-on-Tyne	Sept. 4, 1869
560	SPENCER, T., Ryton, Newcastle-on-Tyne	Dec. 6, 1866
561	SPENCER, W., Cross House Chambers, Westgate Road, Newcastle ...	Aug. 21, 1852
562	STEAVENSON, A. L., Durham ... ... (VICE-PRESIDENT)	Dec. 6, 1855
563	STEAVENSON, D. F., B.A., LL.B., Barrister-at-Law, Cross House, Westgate Road, Newcastle-on-Tyne	April 1, 1871

		ELECTED.
564	STEELE, CHAS., Bolton Colliery, Mealsgate, Cumberland	June 7, 1873
565	STEELE, CHARLES R., Almburgh House, near Maryport	Mar. 3, 1864
566	STEPHENSON, G. R., 9, Victoria Chambers, Westminster, London, S.W.	Oct. 4, 1860
567	STEPHENSON, W. H., Elswick House, Newcastle-on-Tyne	Mar. 7, 1867
568	STEVENSON, R.	Feb. 5, 1876
569	STOBART, W., Wearmouth Colliery, Sunderland	July 2, 1872
570	STOKOE, JOSEPH, Houghton-le-Spring, Fence Houses	April 11, 1874
571	STOREY, THOS. E., Clough Hall Iron Works, Kidsgrove, Staffordshire	Feb. 5, 1876
572	STRAKER, JOHN, Stagshaw House, Corbridge-on-Tyne	May 2, 1867
573	STRAKER, J. H., Willington House, Co. Durham	Oct. 3, 1874
574	STRATTON, T. H. M., Seaham Colliery, Sunderland	Dec. 3, 1870
575	SWALLOW, J., Pontop Hall, Lintz Green	May 2, 1874
576	SWALLOW, R. T., Springwell, Gateshead	1862
577	SWAN, H. F., Shipbuilder, Newcastle-on-Tyne	Sept. 2, 1871
578	SWAN, J. G., Upsall Hall, near Middlesbro'	Sept. 2, 1871
579	SWANN, C. G., Sec., General Mining Asso. Ld., 6, New Broad St., London	Aug. 7, 1875
580	TATE, SIMON, Kimblesworth Colliery, Co. Durham	Sept. 11, 1875
581	TAYLOR, GEORGE, Brotton Mines, Saltburn-by-the-Sea	June 5, 1875
582	TAYLOR, HUGH, King Street, Quay, Newcastle-on-Tyne	Sept. 5, 1856
583	TAYLOR, JOHN B., Wollescote House, near Stourbridge	May 3, 1873
584	TAYLOR, T., King Street, Quay, Newcastle-on-Tyne	July 2, 1872
585	TAYLOR-SMITH, THOMAS, Urpeth Hall, Chester-le-Street	Aug. 2, 1866
586	THOMAS, A., Bilson House, near Newnham, Gloucestershire	Mar. 2, 1872
587	THOMPSON, JAMES, Hurworth, Darlington	June 2, 1866
588	THOMPSON, JOHN, Boughton Hall, Chester	Sept. 2, 1865
589	THOMPSON, J., Hilton House, Blackrod, near Chorley...	April 6, 1867
590	THOMPSON, R., Jun., Rodridge House, Wingate, Co. Durham ...	Sept. 7, 1867
591	THOMPSON, T. C., Milton Hall, Carlisle	May 4, 1854
592	THOMSON, JOHN, South Skelton Mines, *via* Guisbro'	April 7, 1877
593	THOMSON, JOS. F., Manvers Main Colliery, Rotherham	Feb. 6, 1875
594	THUBRON, N., Broadoak Colliery, Longhor, near Swansea	Oct. 3, 1874
595	TINN, J., C.E., Ashton Iron Rolling Mills, Bower Ashton, Bristol ...	Sept. 7, 1867
596	TONE, J. F., C.E.	Feb. 7, 1856
597	TYLDEN-WRIGHT, C., Shireoaks Colliery, Worksop, Notts	1862
598	TYLOR, ALFRED E., 123, Bute Street, Cardiff	April 1, 1876
599	TYSON, WM. JOHN, 1, Lowther Street, Whitehaven	Mar. 3, 1877
600	TYZACK, D., Kelung, Formosa Island, c/o Com. of Customs, Amoy, China	Feb. 14, 1874
601	TYZACK, WILFRED, Tanfield Lea Coll., Lintz Green Station, Newcastle	Oct. 7, 1876
602	URE, J. F., Engineer, Tyne Commissioners, Newcastle	May 8, 1869
603	VIVIAN, JOHN, Diamond Boring Company, Whitehaven	Mar. 3, 1877
604	WADHAM, E., C. and M.E., Millwood, Dalton-in-Furness	Dec. 7, 1867
605	WAKE, H. H., River Wear Commissioners, Sunderland	Feb. 3, 1872
606	WALKER, G. B., Wharncliffe Silkstone Collieries, Wortley, nr. Sheffield	Dec. 2, 1871

		ELECTED.
607	WALKER, J. S., 15, Wallgate, Wigan, Lancashire	Dec. 4, 1869
608	WALKER, W., Saltburn-by-the-Sea	Mar. 5, 1870
609	WALLACE, HENRY, Trench Hall, Gateshead	Nov. 2, 1872
610	WALTON, W., Upleatham Mines, Marske-by-the-Sea	Feb. 1, 1867
611	WARD, H., Rodbaston Hall, near Penkridge, Stafford...	Mar. 6, 1862
612	WARDALE, JOHN D., M.E., Redheugh Engine Works, Gateshead ...	May 1, 1875
613	WARDELL, S. C., Doe Hill House, Alfreton	April 1, 1865
614	WARRINGTON, J., Worsborough Hall, near Barnsley	Oct. 6, 1859
615	WATSON, H., High Bridge Works, Newcastle-on-Tyne	Mar. 7, 1868
616	WATSON, H. B., High Bridge Works, Newcastle-on-Tyne	Mar. 3, 1877
617	WATSON, M., Flimby and Broughton Moor Collieries, near Maryport..	Mar. 7, 1868
618	WEBSTER, R. C., Bangor Isycoed, near Wrexham, North Wales ...	Sept. 6, 1855
619	WEEKS, J. G., Bedlington Colliery, Bedlington *(Member of Council)*	Feb. 4, 1865
620	WESTMACOTT, P. G. B., Elswick Iron Works, Newcastle	June 2, 1866
621	WHATELY, W. L., Wearmouth Colliery, Sunderland	Dec. 4, 1875
622	WHITE, H., Weardale Coal Company, Towlaw, near Darlington ...	1866
623	WHITE, J. F., M.E., Wakefield	July 2, 1872
624	WHITE, J. W. H., Woodlesford, near Leeds	Sept. 2, 1876
625	WHITEHEAD, JAMES, Brindle Lodge, near Preston, Lancashire ...	Dec. 4, 1875
626	WHITELAW, JOHN, 118, George Street, Edinburgh	Feb. 5, 1870
627	WHITELAW, T., Shields and Dalzell Collieries, Motherwell	April 6, 1872
628	WHITTEM, THOS. S., Wyken Colliery, near Coventry	Dec. 5, 1874
629	WIDDAS, C., North Bitchburn Colliery, Howden, Darlington... ...	Dec. 5, 1868
630	WIGHT, W. H., Cowpen Colliery, Blyth...	Feb. 3, 1877
631	WILD, J. G., Ellistown Colliery, Ellistown, near Leicester	Oct. 5, 1867
632	WILLIAMS, E., Cleveland Lodge, Middlesbro'	Sept. 2, 1865
633	WILLIAMS, J. J., Pantgwyn House, Holywell, Flintshire	Nov. 2, 1872
634	WILLIAMSON, JOHN, Chemical Manufacturer, South Shields... ...	Sept. 2, 1871
635	WILLIAMSON, JOHN, Cannock, &c., Collieries, Hednesford	Nov. 2, 1872
636	WILLIS, J., 14, Portland Terrace, Newcastle-on-Tyne...	Mar. 5, 1857
637	WILSON, J., 69, Great Clyde Street, Glasgow...	July 2, 1872
638	WILSON, J. B., Wingfield Iron Works and Colliery, Alfreton... ...	Nov. 5, 1852
639	WILSON, ROBERT, Flimby Colliery, Maryport	Aug. 1, 1874
640	WILSON, W. B., Kippax and Allerton Collieries, Leeds	Feb. 6, 1869
641	WINTER, T. B., Grey Street, Newcastle-on-Tyne	Oct. 7, 1871
642	WOOD, C. L., Freeland, Bridge of Earn, Perthshire	1853
643	WOOD, LINDSAY, Southill, Chester-le-Street (PAST PRESIDENT, *Member of Council)*	Oct. 1, 1857
644	WOOD, THOMAS, Rainton House, Fence Houses	Sept. 3, 1870
645	WOOD, W. H., West Hetton, Ferryhill	1856
646	WOOD, W. O., East Hetton Colliery, Coxhoe, Co. Durham	Nov. 7, 1863
647	WOOLCOCK, HENRY, St. Bees, Cumberland	Mar. 3, 1873
648	WRIGHT, G. H., 12, Trumpington Street, Cambridge	July 2, 1872
649	WRIGHT, J. M., 20, Summerhill Terrace, Newcastle-on-Tyne ...	Aug. 5, 1876
650	WRIGHTSON, T., Stockton-on-Tees	Sept. 13, 1873
651	YOUNG, PHILIP, Cae-pen-ty Colliery, Frood, near Wrexham	Oct. 11, 1873

Ordinary Members.

		ELECTED.
1	ACKROYD, WM., Jun., M.E., Morley Main Collieries, Morley, nr. Leeds	Feb. 7, 1880
2	BELL, C. E., Park House, Durham	Dec. 3, 1870
3	BRAMALL, HENRY, M.I.C.E., St. Helen's, Lancashire	Oct. 5, 1878
4	BUTLER, W. F., C.E., 6, Queen Anne's Gate, Westminster, London, S.W.	Feb. 7, 1880
5	DACRES, THOMAS, Dearham Colliery, Maryport	May 4, 1878
6	DIXON, JAMES S., 170, Hope Street, Glasgow	Aug. 3, 1878
7	ELLIS, W. R., F.G.S., Wigan	June 1, 1878
8	GILCHRIST, THOMAS, Eltringham, Prudhoe-on-Tyne	May 4, 1878
9	GOUDIE, J. H., 13, Lowther Street, Whitehaven	Sept. 7, 1878
10	HARDEN, JOHN HENRY, Phenix Iron Works, Phenixville, Chester County, Pennsylvania, U.S.A.	June 1, 1878
11	KELLETT, WILLIAM, Wigan	June 1, 1878
12	LANCASTER, JOHN, Auchinbeath, &c., Collieries, Lanarkshire ...	Sept. 7, 1878
13	LAWRENCE, ARTHUR, 72, Crockherbtown, Cardiff	May 3, 1879
14	MARTIN, TOM PATTINSON, Allhallows Colliery, Mealsgate, Carlisle ...	Feb. 15, 1879
15	PEASE, J., Mitcheldean, near Gloucester...	Mar. 2, 1878
16	POTTS, JOS., Jun., Architect, &c., North Cliff, Roker, Sunderland ...	Dec. 6, 1879
17	PRIOR, EDWARD G., Inspector of Mines, Nanaims, British Columbia...	Feb. 7, 1880
18	ROGERS, WILLIAM, M.E., 19, King Street, Wigan	Nov. 2, 1878
19	RUSSELL, ROBERT, M.E., Coltness Iron Works, Newmains, N.B. ...	Aug. 3, 1878
20	SPENCER, JOHN W., Newburn, near Newcastle-on-Tyne	May 4, 1878
21	TOPPING, WALTER, Messrs. Cross, Tetley, & Co., Platt Bridge, Wigan	Mar. 2, 1878
22	WINSTANLEY, ROBT., M.E., 32, St. Ann's Street, Manchester... ...	Sept. 7, 1878

Associate Members.

1	BACON, ARTHUR H., Murton Colliery, Sunderland	Nov. 3, 1877
2	BAILES, E. T., Wingate, Ferryhill	June 7, 1879
3	BARRETT, CHARLES ROLLO, Burnhope House, Lanchester	Nov. 7, 1874
4	BERKLEY, R. W., Marley Hill, Colliery, Gateshead	Feb. 14, 1874
5	BEWICK, T. B., Haydon Bridge, Northumberland	Mar. 7, 1874
6	BROUGH, THOMAS, Seaham Colliery, Seaham Harbour	Feb. 1, 1873
7	BROWN, M. W., 7, Elswick Park, Newcastle-on-Tyne	Oct. 7, 1871
8	BROWN, W. B., Springfield, Wavertree, Liverpool	Mar. 2, 1878
9	BRUCE, JOHN, 2, Framlington Place, Newcastle-on-Tyne	Feb. 14, 1874
10	BURNLEY, E. F., Whitwood Collieries, Normanton	April 11, 1874
11	CABRERA, FIDEL, c/o H. Kendall & Son, 12, Gt. Winchester St., London	Oct. 6, 1877
12	CHAMBERS, W. HENRY, 15, Victoria Road, Barnsley	Dec. 2, 1871
13	CLARK, ROBT., Garnant Collieries, Cwmaman, nr. Llanelly, So. Wales	Sept. 11, 1875
14	CLOUGH, JAMES, Bedlington Collieries, near Morpeth...	April 5, 1873
15	CLOVIS, LOUIS, 1, Borough Houses, Gateshead-on-Tyne	Feb. 15, 1879
16	COCHRANE RALPH D., Hetton Colliery Offices, Fence Houses ...	June 1, 1878

		ELECTED.
17	DALZIEL, W. G., 2, Pembroke Terrace, Cardiff	Sept. 7, 1878
18	DODD, M., Jun., Heddon Colliery, Wylam-on-Tyne	Dec. 4, 1875
19	DOYLE, JOHN ELYOTT, B.A.	Mar. 1, 1879
20	DOYLE, PATRICK, C.E., F.M.S., F.L.S., M.R.A.S., Municipal Chambers, Charters Towers, *via* Townsville, Queensland, Australia	Mar. 1, 1879
21	DOUGLAS, M. H., Whitburn Colliery, Sunderland	Aug. 2, 1879
22	EDEN, C. H., Etherley House, Darlington	Sept. 13, 1873
23	EDGE, JOHN H., Coalport Wire Rope and Chain Works, Shifnal, Salop	Sept. 7, 1878
24	GAMBIER, G. G. C....	Aug. 3, 1878
25	GERRARD, JAMES, Ince Hall Coal and Cannel Company, Wigan ...	Mar. 3, 1873
26	GREENER, T. Y., Rainford Collieries, St. Helen's, Lancashire... ...	July 2, 1872
27	GREENER, W. J., Pemberton Colliery, Wigan	Mar. 2, 1878
28	GRESLEY, W. S., Overseale, Ashby-de-la-Zouch	Oct. 5, 1878
29	HAMILTON, E., Rig Wood, Saltburn-by-the-Sea	Nov. 1, 1873
30	HARRIS, W. S., Sheep Hill, Burnopfield, near Lintz Green	Feb. 14, 1874
31	HARRISON, J. W., M.E., Gildersome, near Leeds	Aug. 3, 1878
32	HUGHES, E. G., Solway View, Whitehaven	June 1, 1878
33	HUMBLE, STEPHEN, Uttoxeter Road, Derby	Oct. 6, 1877
34	JEPSON, H., Ebbw Vale Works, Ebbw Vale, Mon.	July 2, 1872
35	JOHNSON, W., Abram Colliery, Wigan	Feb. 14, 1874
36	LISLE, J., Washington Colliery, County Durham	July 2, 1872
37	LYON, JAMES, Vale View, Whitehaven	Mar. 3, 1877
38	MACCABE, H. O., Chilton Colliery, Ferryhill	Sept. 7, 1878
39	MARKHAM, G. E., Howlish Offices, Bishop Auckland	Dec. 4, 1875
40	MILLER, D. S., Wearmouth Colliery, Sunderland	Nov. 7, 1874
41*	MILLER, N., Kurhurballee Coll., East India Railway, Chord Line, Bengal	Oct. 5, 1878
42	PRICHARD, WM., Navigation and Deep Duffryn Collieries, Mountain Ash, South Wales	Dec. 7, 1878
43	RATHBONE, EDGAR P., Ecole des Mines, Liège, Belgium	Mar. 7, 1874
44	RYLANDS, RICHARD A., Haford Las, Minera, Wrexham	June 1, 1878
45	SAISE, WALT., D. Sc., E.I.R. Collieries, Giridi, Bengal	Nov. 3, 1877
46	SAWYER, A. R., Ass. R.S.M., Basford, Stoke-upon-Trent	Dec. 6, 1873
47	SEYMOUR, T. M., Lambton Colls., Waratah, nr. Newcastle, New S. Wales	Dec. 4, 1875
48	SMITH, J. BAGNOLD, The Laurels, Chesterfield...	Nov. 2, 1878
49	STOBART, F. Blue House, Washington, Co. Durham	Aug. 2, 1873
50	STONES, T. H., Wigan Coal & Iron Co., Westleigh, nr. Leigh, Lancashire	Nov. 7, 1874
51	TURNBULL, GEORGE, Seaham Colliery, Seaham Harbour	Oct. 4, 1879
52	THOMPSON, JOHN, Heworth Colliery, County Durham	Dec. 7, 1878

Students.

		ELECTED.
1	ARMITAGE, MATTHEW, Birtley, near Chester-le-Street	Oct. 6, 1877
2	ATKINSON, A. A., Munglepore Colliery, Bengal, India	Aug. 3, 1878
3	ATKINSON, E. E., Westbourne House, Long Benton	Nov. 4, 1876
4	ATKINSON, FRED., Ackhurst Hall, Wigan	Feb. 14, 1874
5	AYTON, E. F., Lumley Colliery, Fence Houses	Feb. 5, 1876
6	AYTON, HENRY, Seaton Delaval Colliery, Dudley, Northumberland ...	Mar. 6, 1875
7	BARNES, A. W., Grassmore Colliery, near Chesterfield	Oct. 5, 1872
8	BAUMGARTNER, W. O., 41, Wharncliffe Street, Newcastle-on-Tyne ...	Sept. 6, 1879
9	BELL, GEO. FRED., 13, Old Elvet, Durham	Sept. 6, 1879
10	BIRD, HARRY, Little Hatherley, Cheltenham	April 7, 1877
11	BIRD, W. J., Wingate Colliery, Durham	Nov. 6, 1875
12	BLACKETT, W. C., 6, Old Elvet, Durham	Nov. 4, 1876
13	BLAKELEY, A. B., Hollyroyd, Dewsbury	Feb. 15, 1879
14	BOWLKER, T. J., Heddon Vicarage, Wylam-on-Tyne	May 5, 1877
15	BRAMWELL, HUGH, Tynemouth	Oct. 4, 1879
16	BROWN, C. GILPIN, Hetton Colliery, Fence Houses	Nov. 4, 1876
17	BUCKHAM, ROBERT, Alderdean House, Lanchester, Durham	Oct. 5, 1878
18	BULMAN, G. H., Ryhope Colliery, Sunderland	April 11, 1874
19	BULMAN, H. F., West Rainton, Fence Houses	May 2, 1874
20	BUNNING, C. Z., Ryton-on-Tyne	Dec. 6, 1873
21	CALDWELL, JOHN S., The Grove, Westhoughton, near Bolton, Lan. ...	Nov. 7, 1874
22	CANDLER, T. E., East Lodge, Crook, Darlington	May 1, 1875
23	CARR, CHARLES B., Castle Eden Colliery, County Durham	May 6, 1876
24	CHAPMAN, ALF. C., Cwmaman Colliery, near Aberdare, South Wales	Oct. 4, 1879
25	CHILD, H., Whitkirk, Leeds	Feb. 15, 1879
26	COBBOLD, C. H., San Valentino, Abruzzo, Citenone, Italy	May 3, 1873
27	COCKBURN, W. C., 8, Summerhill Grove, Newcastle-on-Tyne	July 2, 1872
28	COX, L. CLIFFORD, Ravenstone, near Ashby-de-la-Zouch	April 1, 1876
29	CRAIG, ERNEST, Silksworth Colliery, near Sunderland	Nov. 3, 1877
30	CRAWFORD, T. W., Peases' West Collieries, Crook, by Darlington ...	Dec. 4, 1875
31	CRONE, F. E., Killingworth House, near Newcastle	Sept. 2, 1876
32	DAVIDSON, C. C., Ore Bank House, Bigrigg, *via* Carnforth, Cumberland	Nov. 4, 1876
33	DAVIS, KENNETH M., Towneley and Stella Collieries, Ryton-on-Tyne	April 5, 1879
34	DEPLEDGE, M. F., Satley Vicarage, Darlington	April 7, 1877
35	DONKIN, WM., Usworth Colliery, Washington Station, Co. Durham ...	Sept. 2, 1876
36	DORMAN, FRANK, The Palace, Maidstone, Kent	May 1, 1875
37	DOUGLAS, ARTHUR STANLEY, Harton Colliery, near South Shields ...	June 1, 1878
38	DOWSON, W. C., Belle Vue House, Escomb, near Bishop Auckland ...	Mar. 2, 1878
39	DUNN, A. F., Poynton, Stockport, Cheshire	June 2, 1877
40	DURNFORD, H. ST. JOHN, Wharncliffe Silkstone Coll., Wortley, Sheffield	June 2, 1877

		ELECTED.
41	EDGE, J. C., Ince Hall Coal and Cannel Company, Limited, Wigan ...	Dec. 5, 1874
42	EVANS, DAVID L., Goldtops, Newport, Monmouthshire	May 4, 1878
43	FENWICK, J. W., Bebside Colliery, Cowpen Lane, Northumberland ...	Oct. 7, 1876
44	FLETCHER, JOHN E., Ellesmere Park, Eccles, near Manchester ...	Dec. 1, 1877
45	FORSTER, THOMAS E., Backworth, Newcastle-on-Tyne	Oct. 7, 1876
46	FORSYTH, FRANK W.	Dec. 2, 1876
47	FOWLER, ROBERT, Wearmouth Colliery, Sunderland	Dec. 2, 1876
48	FRYAR, MARK, Denby Colliery, Derby	Oct. 7, 1876
49	GILCHRIST, J. R., Newbottle Colliery Offices, Fence Houses	Feb. 3, 1877
50	GORDON, CHAS., Longton Hall Colliery, Stoke-on-Trent	May 5, 1877
51	GOULD, ALEX., Cowpen Colliery, Blyth	Dec. 1, 1877
52	GUTHRIE, JAMES KENNETH, Ryton-on-Tyne	Mar. 1, 1879
53	HADDOCK, W. T., Jun., Ryhope Colliery, Sunderland	Oct. 7, 1876
54	HALLAS, G. H., Hindley Green Colliery, near Wigan	Oct. 7, 1876
55	HALLIMOND, W. T., 55, Western Hill, Durham	May 2, 1874
56	HARE, SAMUEL, Gladstone Street, Crook	Aug. 2, 1879
57	HARRISON, ROBERT J., Backworth Colliery, near Newcastle-on-Tyne	May 1, 1875
58	HARRISON, R. W., Public Wharf, Leicester	Mar. 3, 1877
59	HEDLEY, E., Rainham Lodge, The Avenue, Beckenham, Kent ...	Dec. 2, 1871
60	HEDLEY, ERNEST H., West Chirton House, Percy Main	Oct. 7, 1876
61	HEDLEY, SEPT. H., Londonderry Offices, Seaham Harbour	Feb. 15, 1879
62	HENDY, J. C. B., Usworth Colliery, Washington Station, Co. Durham	Sept. 2, 1876
63	HILL, LEONARD, No. 4, Brancepeth, Durham	Oct. 6, 1877
64	HOWARD, WALTER, 13, Cavendish Street, Chesterfield	April 13, 1878
65	HUDSON, JOSEPH G. S., Albion Mines, Pictou County, Nova Scotia ...	Mar. 2, 1878
66	HUMBLE, JOICEY, 17, Westmorland Terrace, Newcastle-on-Tyne ...	Mar. 3, 1877
67	HUMBLE, ROBERT, 17, Westmorland Terrace, Newcastle-on-Tyne ...	Sept. 2, 1876
68	HUNTER, JOHN P., Backworth Colliery, near Newcastle-on-Tyne ...	Oct. 6, 1877
69	JOBLING, THOS. E., Coxlodge Colliery, by Kenton, Newcastle-on-Tyne	Oct. 7, 1876
70	JORDAN, J. J., South Derwent Colliery, *via* Lintz Green	Mar. 3, 1873
71	KAYLL, A. C., Felling Colliery, Gateshead	Oct. 7, 1876
72	KIRKHOUSE, E. G., Medomsley, Newcastle-on-Tyne	Aug. 3, 1878
73	KIRKUP, PHILIP, Peases' West Collieries, by Darlington	Mar. 2, 1878
74	KIRTON, HUGH, Browney Colliery, Durham	April 7, 1877
75	LEACH, C. C., Bedlington Collieries, Bedlington	Mar. 7, 1874
76	LIDDELL, J. M., Colliery Office, Whitehaven	Mar. 6, 1875
77	LINDSAY, CLARENCE S., Marsden, South Shields	Mar. 4, 1876
78	LIVEING, E. H., 52, Queen Anne Street, Cavendish Square, London	Sept. 1, 1877
79	LOCKE, ERNEST G., Ellistown Colliery, Bagworth, near Leicester ...	Dec. 2, 1876
80	LONGBOTHAM, R. H., Hamsteels Colliery, near Durham	Sept. 2, 1876

		ELECTED.
81	MACKINLAY, THOS. B., West Pelton Colliery, Chester-le-Street ...	Nov. 1, 1879
82	MADDISON, THOS. R., Thornhill Collieries, near Dewsbury	Mar. 3, 1877
83	MAKEPEACE, H. R., Heworth Colliery Offices, Heworth, near Newcastle	Mar. 3, 1877
84	MELLY, EDWARD F., Nunnery Colliery Offices, Sheffield	Oct. 5, 1878
85	MOREING, C. A., 37, Spring Gardens, London	Nov. 7, 1874
86	MUNDLE, ROBERT, Leam Cottage, Woodburn	Mar. 6, 1875
87	MURRAY, W. C., South Derwent Colliery, *via* Lintz Green Station, Annfield Plain	Oct. 4, 1879
88	MURTON, CHARLES J., Jesmond Villas, Newcastle-on-Tyne	Mar. 6, 1880
89	NICHOLSON, JOS. C., Newbottle Colliery, Fence Houses	Feb. 3, 1877
90	NOBLE, J. C., Usworth Hall, near Washington Station, Co. Durham...	May 5, 1877
91	ORNSBY, R. E., Seaton Delaval Colliery, Dudley, Northumberland ..	Mar. 6, 1875
92	PALMER, HENRY, Nunnery Colliery, Sheffield	Nov. 2, 1878
93	PATTISON, JOS. W., Londonderry Offices, Seaham Harbour	Feb. 15, 1879
94	PEAKE, CHARLES EDWD., Houghton Colliery, Barnsley	Nov. 3, 1877
95	PEAKE, R. C., Harton Colliery Offices, South Shields	Feb. 7, 1880
96	PEART, A. W., Cwmaman Colliery Offices, Aberdare	Nov. 4, 1876
97	PICKERING, W. H., College of Physical Science, Newcastle	Mar. 2, 1878
98	PICKSTONE, WM., Oak Bank, Black Lane, near Manchester	Sept. 11, 1875
99	POCOCK, FRANCIS A., "Wellesley," South Shields	Mar. 6, 1875
100	POTTER, E. A., Cramlington House, Northumberland	Feb. 6, 1875
101	PREST, J. J., St. Helen's Colliery, Bishop Auckland	May 1, 1875
102	PRICE, STEPHEN RICHARD, St. Alban's Place, Tynemouth	Nov. 3, 1877
103	PROCTOR, C. P., Killingworth Colliery, Newcastle	Oct. 7, 1876
104	REED, R., Cowpen Colliery, Blyth	Feb. 3, 1877
105	REES, ERNEST P., Langley Park Colliery, Durham	Mar. 4, 1876
106	RICHARDSON, R. W. P., 2, Ridley Street, Blackhill, Co. Durham ...	Mar. 4, 1876
107	ROBINSON, FRANK, Denton Hall, Darlington	Sept. 2, 1876
108	ROBINSON, GEO., Hebburn Colliery, near Newcastle-on-Tyne	Nov. 4, 1876
109	ROBSON, HARRY N., 3, North Bailey, Durham	Dec. 4, 1875
110	ROBSON, THOS. O., The Vicarage, Marske-by-the-Sea	Sept. 11, 1875
111	ROUTLEDGE, W. H., Staveley Coal and Iron Co. Limited, Chesterfield	Oct. 7, 1876
112	SCARTH, R. W., Stanghow House, Stanghow, near Guisbro'	Dec. 4, 1875
113	SCHIER, H. C., East Hetton Colliery Offices, Coxhoe, Co. Durham ...	Dec. 4, 1875
114	SCOTT, ALEX., Lofthouse Colliery, Limited, Wakefield	Mar. 2, 1878
115	SCOTT, WALTER, Cornsay Colliery, Lanchester...	Sept. 6, 1879
116	SCOTT, WM., Brancepeth Colliery Offices, Willington, Co. Durham ...	Mar. 4, 1876
117	SMITH, T. F., Jun., Cinderford Villas, near Newnham, Gloucestershire	May 5, 1877
118	SMITH, THOS., Leadgate, County Durham	Feb. 15, 1879
119	SOUTHERN, E. O., 5, Fenwick Terrace, Jesmond, Newcastle	Dec. 5, 1874
120	SOUTHERN, W. J.	Aug. 1, 1874
121	SPENCE, R. F., Cramlington	Nov. 2, 1878
122	STOKER, ARTHUR P., Birtley, near Chester-le-Street	Oct. 6, 1877

		ELECTED.
123	TELFORD, W. H., Cramlington Colliery, Northumberland	Oct. 3, 1874
124	THOMPSON, WILLIAM	May 2, 1874
125	TODD, JOHN T., Hetton-le-Hole, Fence Houses...	Nov. 4, 1876
126	TODNER, W. J. S., 6, George's Road, Elswick, Newcastle-on-Tyne ...	Sept. 6, 1879
127	TOPHAM, EDWARD C., Houghton Main Colliery, Darfield, near Barnsley	Nov. 3, 1877
128	TUCKER, A. W., Turk's Head Brewery, Gateshead	Dec. 2, 1876
129	VERNES, AMIDEE, 8, Claremont Place, Gateshead	May 4, 1878
130	WALKER, F. W., Aldbro', Darlington	Sept. 2, 1876
131	WALKER, SMART, Ryhope Colliery, near Sunderland	Dec. 4, 1875
132	WALTON, J. C., Heworth Colliery, near Newcastle-on-Tyne	Nov. 7, 1874
133	WHITE, C. E., Hebburn Colliery, near Newcastle-on-Tyne	Nov. 4, 1876
134	WILSON, J. D., 8, Walker Terrace, Gateshead-on-Tyne	Sept. 11, 1875
135	WILSON, J. T., Blackhill, Richmond	Nov. 7, 1874
136	WOOD, A. E.	Dec. 2, 1876

Subscribing Collieries.

1 Ashington Colliery, Newcastle-on-Tyne.
2 Haswell Colliery, Fence Houses.
3 Hetton Collieries, Fence Houses.
4 Lambton Collieries, Fence Houses.
5 North Hetton Colliery, Fence Houses.
6 Londonderry Collieries.
7 Ryhope Colliery, near Sunderland.
8 Seghill Colliery, Northumberland.
9 South Hetton and Murton Collieries.
10 Stella Colliery, Hedgefield, Blaydon-on-Tyne.
11 Throckley Colliery, Newcastle-on-Tyne.
12 Wearmouth Colliery, Sunderland.
13 Whitworth Colliery, Ferryhill.

CHARTER

OF

THE NORTH OF ENGLAND

Institute of Mining and Mechanical Engineers.

FOUNDED 1852.

INCORPORATED NOVEMBER 28TH, 1876.

Victoria, by the Grace of God, of the United Kingdom of Great Britain and Ireland, Queen, Defender of the Faith, TO ALL TO WHOM THESE PRESENTS SHALL COME, GREETING:

WHEREAS it has been represented to us that NICHOLAS WOOD, of Hetton, in the County of Durham, Esquire (since deceased); THOMAS EMERSON FORSTER, of Newcastle-upon-Tyne, Esquire (since deceased); SIR GEORGE ELLIOT, Baronet (then George Elliot, Esquire), of Houghton Hall, in the said County of Durham, and EDWARD FENWICK BOYD, of Moor House, in the said County of Durham, Esquire, and others of our loving subjects, did, in the year one thousand eight hundred and fifty-two, form themselves into a Society, which is known by the name of THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, having for its objects the Prevention of Accidents in Mines and the Advancement of the Sciences of Mining and Engineering generally, of which Society LINDSAY WOOD, of Southill, Chester-le-Street, in the County of Durham, Esquire, is the present President. AND WHEREAS it has been further represented to us that the Society was not constituted for gain, and that neither its projectors nor Members derive nor have derived pecuniary profit from its prosperity; that it has during its existence of a period of nearly a quarter of a century steadily devoted itself to the preservation of human life and the safer development of mineral property; that it has contributed substantially and beneficially to the prosperity of the country and the welfare and happiness of the working members of the community; that the Society has since its establishment diligently pursued its aforesaid objects, and in so doing has made costly experiments

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and researches with a view to the saving of life by improvements in the ventilation of mines, by ascertaining the conditions under which the safety lamp may be relied on for security; that the experiments conducted by the Society have related to accidents in mines of every description, and have not been limited to those proceeding from explosions; that the various modes of getting coal, whether by mechanical appliances or otherwise, have received careful and continuous attention, while the improvements in the mode of working and hauling belowground, the machinery employed for preventing the disastrous falls of roof underground, and the prevention of spontaneous combustion in seams of coal as well as in cargoes, and the providing additional security for the miners in ascending and descending the pits, the improvements in the cages used for this purpose, and in the safeguards against what is technically known as "overwinding," have been most successful in lessening the dangers of mining, and in preserving human life; that the Society has held meetings at stated periods, at which the results of the said experiments and researches have been considered and discussed, and has published a series of Transactions filling many volumes, and forming in itself a highly valuable Library of scientific reference, by which the same have been made known to the public, and has formed a Library of Scientific Works and Collections of Models and Apparatus, and that distinguished persons in foreign countries have availed themselves of the facilities afforded by the Society for communicating important scientific and practical discoveries, and thus a useful interchange of valuable information has been effected; that in particular, with regard to ventilation, the experiments and researches of the Society, which have involved much pecuniary outlay and personal labour, and the details of which are recorded in the successive volumes of the Society's Transactions, have led to large and important advances in the practical knowledge of that subject, and that the Society's researches have tended largely to increase the security of life; that the Members of the Society exceed 800 in number, and include a large proportion of the leading Mining Engineers in the United Kingdom. AND WHEREAS in order to secure the property of the Society, and to extend its useful operations, and to give it a more permanent establishment among the Scientific Institutions of our Kingdom, we have been besought to grant to the said LINDSAY WOOD, and other the present Members of the Society, and to those who shall hereafter become Members thereof, our Royal Charter of Incorporation. NOW KNOW YE that we, being desirous of encouraging a design so laudable and salutary of our special grace, certain knowledge, and mere motion, have willed granted, and declared, and

do, by these presents, for us, our heirs, and successors, will, grant, and declare, that the said LINDSAY WOOD, and such others of our loving subjects as are now Members of the said Society, and such others as shall from time to time hereafter become Members thereof, according to such Bye-laws as shall be made as hereinafter mentioned, and their successors, shall for ever hereafter be, by virtue of these presents, one body, politic and corporate, by the name of "THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS," and by the name aforesaid shall have perpetual succession and a Common Seal, with full power and authority to alter, vary, break, and renew the same at their discretion, and by the same name to sue and be sued, implead and be impleaded, answer and be answered unto, in every Court of us, our heirs and successors, and be for ever able and capable in the law to purchase, acquire, receive, possess, hold, and enjoy to them and their successors any goods and chattels whatsoever, and also be able and capable in the law (notwithstanding the statutes and mortmain) to purchase, acquire, possess, hold and enjoy to them and their successors a hall or house, and any such other lands, tenements, or hereditaments whatsoever, as they may deem requisite for the purposes of the Society, the yearly value of which, including the site of the said hall or house, shall not exceed in the whole the sum of three thousand pounds, computing the same respectfully at the rack rent which might have been had or gotten for the same respectfully at the time of the purchase or acquisition thereof. AND WE DO HEREBY GRANT our especial licence and authority unto all and every person and persons and bodies politic and corporate, otherwise competent, to grant, sell, alien, convey or devise in mortmain unto and to the use of the said Society and their successors, any lands, tenements, or hereditaments not exceeding with the lands, tenements or hereditaments so purchased or previously acquired such annual value as aforesaid, and also any moneys, stocks, securities, and other personal estate to be laid out and disposed of in the purchase of any lands, tenements, or hereditaments not exceeding the like annual value. AND WE FURTHER will, grant, and declare, that the said Society shall have full power and authority, from time to time, to sell, grant, demise, exchange and dispose of absolutely, or by way of mortgage, or otherwise, any of the lands, tenements, hereditaments and possessions, wherein they have any estate or interest, or which they shall acquire as aforesaid, but that no sale, mortgage, or other disposition of any lands, tenements, or hereditaments of the Society shall be made, except with the approbation and concurrence of a General Meeting. And our will and pleasure is, and we further grant and declare that for the better rule

and government of the Society, and the direction and management of the concerns thereof, there shall be a Council of the Society, to be appointed from among the Members thereof, and to include the President and the Vice-Presidents, and such other office-bearers or past office-bearers as may be directed by such Bye-laws as hereinafter mentioned, but so that the Council, including all *ex-officio* Members thereof, shall consist of not more than forty or less than twelve Members, and that the Vice-Presidents shall be not more than six or less than two in number. AND WE DO HEREBY FURTHER will and declare that the said LINDSAY WOOD shall be the first President of the Society, and the persons now being the Vice-Presidents, and the Treasurer and Secretary, shall be the first Vice-Presidents, and the first Treasurer and Secretary, and the persons now being the Members of the Council shall be the first Members of the Council of the Society, and that they respectfully shall continue such until the first election shall be made at a General Meeting in pursuance of these presents. AND WE DO HEREBY FURTHER will and declare that, subject to the powers by these presents vested in the General Meetings of the Society, the Council shall have the management of the Society, and of the income and property thereof, including the appointment of officers and servants, the definition of their duties, and the removal of any of such officers and servants, and generally may do all such acts and deeds as they shall deem necessary or fitting to be done, in order to carry into full operation and effect the objects and purposes of the Society, but so always that the same be not inconsistent with, or repugnant to, any of the provisions of this our Charter, or the Laws of our Realm, or any Bye-law of the Society in force for the time being. AND WE DO FURTHER will and declare that at any General Meeting of the Society, it shall be lawful for the Society, subject as hereinafter mentioned, to make such Bye-laws as to them shall seem necessary or proper for the regulation and good government of the Society, and of the Members and affairs thereof, and generally for carrying the objects of the Society into full and complete effect, and particularly (and without its being intended hereby to prejudice the foregoing generality), to make Bye-laws for all or any of the purposes hereinafter mentioned, that is to say: for fixing the number of Vice-Presidents, and the number of Members of which the Council shall consist, and the manner of electing the President and Vice-Presidents, and other Members of the Council, and the period of their continuance in office, and the manner and time of supplying any vacancy therein; and for regulating the times at which General Meetings of the Society and Meetings of the Council shall be held, and for convening the same and regulating the proceedings thereat, and

for regulating the manner of admitting persons to be Members of the Society, and of removing or expelling Members from the Society, and for imposing reasonable fines or penalties for non-performance of any such Bye-laws, or for disobedience thereto, and from time to time to annul, alter, or change any such Bye-laws so always that all Bye-laws to be made as aforesaid be not repugnant to these presents, or to any of the laws of our Realm. AND WE DO FURTHER will and declare that the present Rules and Regulations of the Society, so far as they are not inconsistent with these presents, shall continue in force, and be deemed the Bye-laws of the Society until the same shall be altered by a General Meeting, provided always that the present Rules and Regulations of the Society and any future Bye-laws of the Society so to be made as aforesaid shall have no force or effect whatsoever until the same shall have been approved in writing by our Secretary of State for the Home Department. IN WITNESS WHEREOF WE HAVE CAUSED THESE OUR LETTERS TO BE MADE PATENT.

Witness Ourself at our Palace, at Westminster, this 28th day of November, in the fortieth year of our reign.

By Her Majesty's Command.

CARDEW.

THE NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

BYE-LAWS

PASSED AT A GENERAL MEETING ON THE 16TH JUNE, 1877.

1.—The members of the North of England Institute of Mining and Mechanical Engineers shall consist of four classes, viz.:—Original Members, Ordinary Members, Associate Members, and Honorary Members, with a class of Students attached.

2.—ORIGINAL MEMBERS shall be those who were Ordinary Members on the 1st of August, 1877.

3.—ORDINARY MEMBERS.—Every candidate for admission into the class of Ordinary Members, or for transfer into that class, shall come within the following conditions:—He shall be more than twenty-eight years of age, have been regularly educated as a Mining or Mechanical Engineer, or in some other recognised branch of Engineering, according to the usual routine of pupilage, and have had subsequent employment for at least five years in some responsible situation as an Engineer, or if he has not undergone the usual routine of pupilage, he must have practised on his own account in the profession of an Engineer for at least five years, and have acquired a considerable degree of eminence in the same.

4.—ASSOCIATE MEMBERS shall be persons practising as Mining or Mechanical Engineers, or in some other recognised branch of Engineering, and other persons connected with or interested in Mining or Engineering.

5.—HONORARY MEMBERS shall be persons who have distinguished themselves by their literary or scientific attainments, or who have made important communications to the Society.

6.—Students shall be persons who are qualifying themselves for the profession of Mining or Mechanical Engineering, or some other of the recognised branches of Engineering, and such persons may continue Students until they attain the age of twenty-three years.

7.—The annual subscription of each Original Member, and of each Ordinary Member who was a Student on the 1st of August, 1877, shall be £2 2s., of each Ordinary Member (except as last mentioned) £3 3s., of each Associate Member £2 2s., and of each Student £1 1s., payable in advance, and shall be considered due on election, and afterwards on the first Saturday in August of each year.

8.—Any Member may, at any time, compound for all future subscriptions by a payment of £25, where the annual subscription is £3 3s., and by a payment of £20 where the annual subscription is £2 2s. All persons so compounding shall be Original, Ordinary, or Associate Members for life, as the case may be; but any Associate Member for life who may afterwards desire to become an Ordinary Member for life, may do so, after being elected in the manner described in Bye-law 13, and on payment of the further sum of £5.

9.—Owners of Collieries, Engineers, Manufacturers, and Employers of labour generally, may subscribe annually to the funds of the Institute, and each such subscriber of £2 2s. annually shall be entitled to a ticket to admit two persons to the rooms, library, meetings, lectures, and public proceedings of the Society; and for every additional £2 2s., subscribed annually, two other persons shall be admissible up to the number of ten persons; and each such Subscriber shall also be entitled for each £2 2s. subscription to have a copy of the Proceedings of the Institute sent to him.

10.—In case any Member, who has been long distinguished in his professional career, becomes unable, from ill-health, advanced age, or other sufficient cause, to carry on a lucrative practice, the Council may, on the report of a Sub-Committee appointed for that purpose, if they find good reason for the remission of the annual subscription, so remit it. They may also remit any arrears which are due from a member, or they may accept from him a collection of books, or drawings, or models, or other contributions, in lieu of the composition mentioned in Bye-law 8, and may thereupon constitute him a Life Member, or permit him to resume his former rank in the Institute.

11.—Persons desirous of becoming Ordinary Members shall be proposed and recommended, according to the Form A in the Appendix, in which form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This form must be signed by the proposer and at least five other Members certifying a personal knowledge of the candidate. The proposal so made being delivered to the Secretary, shall be submitted to the Council, who on approving the qualifications shall determine if the candidate is to be presented for ballot, and if it is so deter-

mined, the Chairman of the Council shall sign such approbation. The same shall be read at the next Ordinary General Meeting, and afterwards be placed in some conspicuous situation until the following Ordinary General Meeting, when the candidate shall be balloted for.

12.—Persons desirous of being admitted into the Institute as Associate Members, or Students, shall be proposed by three Members; Honorary Members shall be proposed by at least five Members, and shall in addition be recommended by the Council, who shall also have the power of defining the time during which, and the circumstances under which, they shall be Honorary Members. The nomination shall be in writing, and signed by the proposers (according to the Form B in the Appendix), and shall be submitted to the first Ordinary General Meeting after the date thereof. The name of the person proposed shall be exhibited in the Society's room until the next Ordinary General Meeting, when the candidate shall be balloted for.

13.—Associate Members or Students, desirous of becoming Ordinary Members, shall be proposed and recommended according to the Form C in the Appendix, in which form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This form must certify a personal knowledge of the candidate, and be signed by the proposer and at least two other Members, and the proposal shall then be treated in the manner described in Bye-law 11. Students may become Associate Members at any time after attaining the age of twenty-three on payment of an Associate Member's subscription.

14.—The balloting shall be conducted in the following manner:—Each Member attending the Meeting at which a ballot is to take place shall be supplied (on demand) with a list of the names of the persons to be balloted for, according to the Form D in the Appendix, and shall strike out the names of such candidates as he desires shall not be elected, and return the list to the scrutineers appointed by the presiding Chairman for the purpose, and such scrutineers shall examine the lists so returned, and inform the meeting what elections have been made. No candidate shall be elected unless he secures the votes of two-thirds of the Members voting.

15.—Notice of election shall be sent to every person within one week after his election, according to the Form E in the Appendix, enclosing at the same time a copy of Form F, which shall be returned by the person elected, signed, and accompanied with the amount of his annual subscription, or life composition, within two months from the date of such election, which otherwise should become void.

16.—Every Ordinary Member elected having signed a declaration in the Form F, and having likewise made the proper payment, shall receive a certificate of his election.

17.—Any person whose subscription is two years in arrear shall be reported to the Council, who shall direct application to be made for it, according to the Form G in the Appendix, and in the event of its continuing one month in arrear after such application, the Council shall have the power, after remonstrance by letter, according to the Form H in the Appendix, of declaring that the defaulter has ceased to be a member.

18.—In case the expulsion of any person shall be judged expedient by ten or more Members, and they think fit to draw up and sign a proposal requiring such expulsion, the same being delivered to the Secretary, shall be by him laid before the Council for consideration. If the Council, after due inquiry, do not find reason to concur in the proposal, no entry thereof shall be made in any minutes, nor shall any public discussion thereon be permitted, unless by requisition signed by one-half the Members of the Institute; but if the Council do find good reason for the proposed expulsion, they shall direct the Secretary to address a letter, according to the Form I in the Appendix, to the person proposed to be expelled, advising him to withdraw from the Institute. If that advice be followed, no entry on the minutes nor any public discussion on the subject shall be permitted; but if that advice be not followed, nor an explanation given which is satisfactory to the Council, they shall call a General Meeting for the purpose of deciding on the question of expulsion; and if a majority of the persons present at such Meeting (provided the number so present be not less than forty) vote that such person be expelled, the Chairman of that Meeting shall declare the same accordingly, and the Secretary shall communicate the same to the person, according to the Form J in the Appendix.

19.—The Officers of the Institute, other than the Treasurer and the Secretary, shall be elected from the Original, Ordinary and Associate Members, and shall consist of a President, six Vice-Presidents, and eighteen Councillors, who, with the Treasurer and the Secretary (if Members of the Institute) shall constitute the Council. The President, Vice-Presidents, and Councillors shall be elected at the Annual Meeting in August (except in cases of vacancies) and shall be eligible for re-election, with the exception of any President or Vice-President who may have held office for the three immediately preceding years, and such six Councillors as may have attended the fewest Council Meetings during the past

year; but such Members shall be eligible for re-election after being one year out of office.

20.—The Treasurer and the Secretary shall be appointed by the Council, and shall be removable by the Council, subject to appeal to a General Meeting. One and the same person may hold both these offices.

21.—Each Original, Ordinary, and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members suitable to fill the offices of President, Vice-Presidents, and Members of Council, for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty. The list so prepared by the Council shall be submitted to the General Meeting in June, and shall be the balloting list for the annual election in August. (See Form K in the Appendix.) A copy of this list shall be posted at least seven days previous to the Annual Meeting, to every Original, Ordinary, and Associate Member; who may erase any name or names from the list, and substitute the name or names of any other person or persons eligible for each respective office; but the number of persons on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the scrutineers. The Votes for any Members who may not be elected President or Vice-Presidents shall count for them as Members of the Council. The Chairman shall appoint four scrutineers, who shall receive the balloting papers, and, after making the necessary scrutiny, destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the Meeting, so as to be received before the appointment of the scrutineers for the election of Officers.

22.—In case of the decease or resignation of any Officer or Officers, the Council, if they deem it requisite that the vacancy shall be filled up, shall present to the next Ordinary General Meeting a list of persons whom they nominate as suitable for the vacant offices, and a new Officer or Officers shall be elected at the succeeding Ordinary General Meeting.

23.—The President shall take the chair at all meetings of the Institute, the Council, and Committees, at which he is present (he being *ex-officio* a member of all), and shall regulate and keep order in the proceedings.

24.—In the absence of the President, it shall be the duty of the senior Vice-President present to preside at the meetings of the Institute, to keep order, and to regulate the proceedings. In case of the absence of the President and of all the Vice-Presidents, the meeting may elect any Member of Council, or in case of their absence, any Member present, to take the chair at the meeting.

25.—The Council may appoint Committees for the purpose of transacting any particular business, or of investigating specific subjects connected with the objects of the Institute. Such Committees shall report to the Council, who shall act thereon as they see occasion.

26.—The Treasurer and the Secretary shall act under the direction and control of the Council, by which body their duties shall from time to time be defined.

27.—The Funds of the Society shall be deposited in the hands of the Treasurer, and shall be disbursed or invested by him according to the direction of the Council.

28.—The Copyright of all papers communicated to, and accepted for printing by the Council, and printed within twelve months, shall become vested in the Institute, and such communications shall not be published for sale or otherwise, without the written permission of the Council.

29.—An Ordinary General Meeting shall be held on the first Saturday of every month (except January and July) at two o'clock, unless otherwise determined by the Council; and the Ordinary General Meeting in the month of August shall be the Annual Meeting, at which a report of the proceedings, and an abstract of the accounts of the previous year, shall be presented by the Council. A Special General Meeting shall be called whenever the Council may think fit, and also on a requisition to the Council, signed by ten or more Members. The business of a Special Meeting shall be confined to that specified in the notice convening it.

30.—At meetings of the Council, five shall be a quorum. The minutes of the Council's proceedings shall be at all times open to the inspection of the Members.

31.—All Past-Presidents shall be *ex-officio* Members of the Council so long as they continue Members of the Institute, and Vice-Presidents who have not been re-elected or have become ineligible from having held office for three consecutive years, shall be *ex-officio* Members of the Council for the following year.

32.—Every question, not otherwise provided for, which shall come before any Meeting, shall be decided by the votes of the majority of the Original, Ordinary, and Associate Members then present.

33.—All papers shall be sent for the approval of the Council at least twelve days before a General Meeting, and after approval, shall be read before the Institute. The Council shall also direct whether any paper read before the Institute shall be printed in the Transactions, and notice shall be given to the writer within one month after it has been read, whether it is to be printed or not.

34.—All proofs of reports of discussions, forwarded to Members for correction, must be returned to the Secretary within seven days from the date of their receipt, otherwise they will be considered correct and be printed off.

35.—The Institute is not, as a body, responsible for the statements and opinions advanced in the papers which may be read, nor in the discussions which may take place at the meetings of the Institute.

36.—Twelve copies of each paper printed by the Institute shall be presented to the author for private use.

37.—Members elected at any meeting between the Annual Meetings shall be entitled to all papers issued in that year, so soon as they have signed and returned Form F, and paid their subscriptions.

38.—The Transactions of the Institute shall not be forwarded to Members whose subscriptions are more than one year in arrear.

39.—No duplicate copies of any portion of the Transactions shall be issued to any of the Members unless by written order from the Council.

40.—Invitations shall be forwarded to any person whose presence at the discussions the Council may think advisable, and strangers so invited shall be permitted to take part in the proceedings but not to vote. Any Member of the Institute shall also have power to introduce two strangers (see Form L) to any General Meeting, but they shall not take part in the proceedings except by permission of the Meeting.

41.—No alteration shall be made in the Bye-laws of the Institute, except at the Annual Meeting, or at a Special Meeting for that purpose, and the particulars of every such alteration shall be announced at a previous Ordinary Meeting, and inserted in its minutes, and shall be exhibited in the room of the Institute fourteen days previous to such Annual or Special Meeting, and such Meeting shall have power to adopt any modification of such proposed alteration of the Bye-laws.

Approved,
R. ASSHETON CROSS.

Whitehall,
2nd July, 1877.

APPENDIX TO THE BYE-LAWS.

[FORM A.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being upwards of twenty-eight years of age, and desirous of being elected an Ordinary Member of the North of England Institute of Mining and Mechanical Engineers, I recommend him from *personal knowledge* as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-law 3.*]

On the above grounds, I beg leave to propose him to the Council as a proper person to be admitted an Ordinary Member.

Signed_____ Member.

Dated this day of 18

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted an ordinary Member.

FROM PERSONAL KNOWLEDGE.

_____
_____
_____
_____
_____ } Five Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a of the North of England Institute of Mining and Mechanical Engineers.

Signed_____ Chairman.

Dated this day of 18

[FORM B.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being desirous of admission into the North of England Institute of Mining and Mechanical Engineers, we, the undersigned, propose and recommend that he shall become [an Honorary Member, or an Associate Member, or a Student] thereof.

_____
_____
_____ } Three* Members.
_____
_____

* If an Honorary Member, five signatures are necessary, and the following Form must be filled in by the Council.

Dated this day of 18

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Honorary Member of the North of England Institute of Mining and Mechanical Engineers.

Signed _____ Chairman.

Dated day of 18

[FORM C.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being at present a of the North of England Institute of Mining and Mechanical Engineers, and upwards of twenty-eight years of age, and being desirous of becoming an Ordinary Member of the said Institute, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the Qualifications of the Candidate according to the spirit of Bye-law 3.*]

On the above grounds, I beg leave to propose him to the Council as a proper person to be admitted an Ordinary Member.

Signed _____ Member.

Dated this day of 18

We, the undersigned, concur in the above recommendation, being

convinced that A. B. is in every respect a proper person to be admitted an Ordinary Member.

FROM PERSONAL KNOWLEDGE.

_____ } Two
_____ } Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Ordinary Member of the North of England Institute of Mining and Mechanical Engineers.

Signed _____ Chairman.

Dated day of 18

[FORM D.]

List of the names of persons to be balloted for at the Meeting on , the day of 18

ORDINARY MEMBERS:—

_____

_____

_____

ASSOCIATE MEMBERS:—

_____

_____

HONORARY MEMBERS:—

_____

_____

STUDENTS:—

_____

_____

Strike out the names of such persons as you desire should *not* be elected, and hand the list to the Chairman.

[FORM E.]

SIR,—I beg leave to inform you that on the day of you were elected a of the North of England Institute of Mining and Mechanical Engineers, but in conformity with its Rules your election cannot be confirmed until the enclosed form be returned to me

with your signature, and until your first annual subscription be paid, the amount of which is £ , or, at your option, the life-composition of £

If the subscription is not received within two months from the present date, the election will become void under Bye-law 15.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM F.]

I, the undersigned, being elected a of the North of England Institute of Mining and Mechanical Engineers, do hereby agree that I will be governed by the Charter and Bye-laws of the said Institute for the time being; and that I will advance the objects of the Institute as far as shall be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to be a Member.

Witness my hand this day of 18

[FORM G.]

Sir,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to draw your attention to Bye-law 17, and to remind you that the sum of £ of your annual subscriptions to the funds of the Institute remains unpaid, and that you are in consequence in arrear of subscription. I am also directed to request that you will cause the same to be paid without further delay, otherwise the Council will be under the necessity of exercising their discretion as to using the power vested in them by the Article above referred to.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM H.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to inform you, that in consequence of non-payment of your arrears of subscription, and in pursuance of Bye-law 17, the Council have determined that unless payment of the amount £ is made previous to the day of next, they will proceed to declare that you have ceased to be a Member of the Institute.

But, notwithstanding this declaration, you will remain liable for payment of the arrears due from you.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM I.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to inform you that, upon mature consideration of a proposal which has been laid before them relative to you, they feel it their duty to advise you to withdraw from the Institute, or otherwise they will be obliged to act in accordance with Bye-law 18.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM J.]

SIR,—It is my duty to inform you that, under a resolution passed at a Special General Meeting of the North of England Institute of Mining and Mechanical Engineers, held on the day of 18 , according to the provisions of Bye-law 18, you have ceased to be a Member of the Institute.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM K.]

BALLOTING LIST.

Ballot to take place at the Meeting of 18 at Two o'Clock.

PRESIDENT—ONE NAME only to be returned, or the vote will be lost.

——— President for the current year eligible for re-election.

——— } New Nominations.

VICE-PRESIDENTS—SIX NAMES only to be returned, or the vote will be lost.

The Votes for any Members who may not be elected as President or Vice-Presidents will count for them as other Members of the Council.

——— } Vice-Presidents for the current year eligible for re-election.

——— } New Nominations.

COUNCIL—EIGHTEEN NAMES only to be returned, or the vote will be lost.

——— } Members of the Council for the current year eligible for re-election.

——— } New Nominations.

Any list returned with a greater number of Names than
ONE PRESIDENT,
SIX VICE-PRESIDENTS,
EIGHTEEN COUNCILLORS,
Will be rejected by the Scrutineers as informal, and the Votes will consequently be lost.

Extract from Bye-law 21.

Each Original, Ordinary, and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members suitable to fill the Offices of President, Vice-Presidents, and Members of Council, for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty. The list so prepared by the Council shall be submitted to the General Meeting in June, and shall be the balloting list for the annual election in August. (See Form K in the Appendix.) A copy of this list shall be posted at least seven days

previous to the Annual Meeting, to every Original, Ordinary, and Associate Member; who may erase any name or names from the list, and substitute the name or names of any other person or persons eligible for each respective office; but the number of persons on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the Scrutineers. The votes for any Members who may not be elected President or Vice-Presidents shall count for them as Members of the Council. The Chairman shall appoint four Scrutineers, who shall receive the balloting papers, and after making the necessary scrutiny destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the Meeting, so as to be received before the appointment of the Scrutineers for the election of Officers.

_____

_____

_____

_____

Names substituted for any of the above are to be written in the blank spaces opposite those they are intended to supersede.

The following Members are ineligible from causes specified in Bye-law 19:—

As President _____

As Vice-President _____

As Councillors _____

[FORM L.]

Admit

of

to the Meeting on Saturday, the

(Signature of Member or Student)

The Chair to be taken at Two o'Clock.

I undertake to abide by the Regulations of the North of England Institute of Mining and Mechanical Engineers, and not to aid in any unauthorised publication of the Proceedings.

(Signature of Visitor)

Not transferable.

NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING, SATURDAY, SEPTEMBER 6TH, 1879, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

E. F. BOYD, ESQ., IN THE CHAIR.

The SECRETARY read the minutes of the last meeting and the minutes of the Council meetings.

The following gentlemen were elected:—

STUDENTS—

Mr. EDWARD FREDERICK BELL, 13, Old Elvet, Durham.
Mr. WALTER SCOTT, Cornsay Colliery, Lanchester.
Mr. W. O. BAUMGARTNER, East Hetton Colliery, Coxhoe, Co. Durham.
Mr. W. J. S. TODNER, Elswick Colliery, Newcastle-on-Tyne.

The following were nominated for election at the next meeting:—

ORDINARY MEMBER—

Mr. C. ERNEST BELL, Park House, Durham.

ASSOCIATE MEMBER—

Mr. GEORGE TURNBULL, Seaham Colliery, Seaham Harbour.

STUDENTS—

Mr. ALFRED CRAWHALL CHAPMAN, Silksworth Hall, Sunderland.
Mr. HUGH BRAMWELL, Tynemouth.
Mr. WM. CUTHBERT MURRAY, So. Derwent Colliery, Annfield Plain, *via* Lintz Green Station.

The SECRETARY read the following paper by Mr. John Daglish, "On an Improved Automatic Expansion Gearing for Winding Engines:"—

ON AN IMPROVED EXPANSION GEARING FOR WINDING ENGINES.

By JOHN DAGLISH.

In a memoir published in Volume XXV. of the Transactions, page 201, the writer described fully the expansion gearing of the large winding engine at Silksworth Colliery, manufactured by Mr. Barclay, of Kilmarnock.

Since then the members of the Institute have had the opportunity of seeing several other applications of expansion gearing on winding engines at the collieries in the north of France, and at the Paris Exhibition of 1878.

Any arrangement for working winding engines expansively ought to possess certain qualifications. The mechanism must be simple, and under the immediate control of the engineman, so as to enable him to work with full steam, not only when changing the tubs, but at any other time when he requires the engine to work at full power. These requirements, coupled with the fact that the engine is reversed each winding, and also requires to be worked with full steam for several strokes at the commencement and termination of the winding, cause the difficulty in the application of expansion to these engines.

The gearing of the Silksworth engine, as described in Volume XXV., met these requirements, and being controlled by the same handle, F, Plate I., as the link, it was necessarily brought into play every winding, which is not the case with a number of other appliances for this purpose. The only drawback, however, to that expansion gearing was that it was a fixed "cut off," *i.e.*, whilst it was capable of being adjusted with great facility by simply turning a screw at the end of the trippet K on the valve lever, it nevertheless required special adjustment, with the engine at rest, whenever it was desired to alter it. The expansion mechanism therefore was under the control of the engineman only so far that he could use it, or not, at will.

Recently, a further important addition has been made to this valve gearing by substituting moveable wedges C for the former screws at K, and

connecting these to a heavy governor B (see Plate I.), and the mechanism is now not only variable throughout the entire winding but is also automatic, it being so arranged that the "cut off" can be reduced by the handle D, independently of the governor, by means of the travel allowed between the nuts L and M, the nut M being always kept up against the governor lever N by means of the weighted weigh bar X; at the same time, should the engine ever run beyond a certain point fixed by the manager of the colliery, the governor takes possession of the expansion gearing and cuts off the steam as much as may be required, and reduces the velocity again.

Practically the working of the mechanism is as follows:—At the commencement of the winding, and for about four revolutions, the engine travels with full steam to acquire a rapid velocity. When the maximum velocity has been acquired, the governor rises, depressing the rod L P, and the lever X, and this alters the position of the wedges C, and so varies the cut off. It will be seen in reference to Figs. 2, 3, and 4, Plate I., that the amount of cut off is regulated by raising the end K of the trippet P, which causes the other end to slip earlier, or later, off the end R of the lever Q. This adjustment was formerly made by means of a screw at K, which had to be adjusted when the engine was at rest; now, however, the requisite alteration is made by the wedges C raising the roller O, which has been secured to the lever. This new cut off arrangement is specially useful when the engine is used for pumping water at nights. Prior to the introduction of this recent mechanism, a limited quantity of steam only was admitted by means of the throttle valve; now the quantity of steam is adjusted by the variable "cut off," and the engine can be made, by means of the small handle D, to travel at any velocity that is required without giving the engineman any more trouble than in turning off the throttle valve. In this case, of course, the governor never comes into play.

It will be observed that there are no springs about the mechanism of this "cut off," or anything that can by any means go wrong. The old arrangement has been in constant operation for five years, drawing upwards of a thousand tons a day, and there has never been the slightest derangement or accident of any kind.

The Indicator Diagrams, given with this improved expansion gearing, are specially interesting. (See Figs. 5 and 6, Plate I.) It will be observed that when working at full pressure both the steam ports or pipes and the exhaust ports or pipes, although they were specially enlarged for this engine, are too small, like those of nearly all engines of great size. The consequence is, that when working during the first four strokes with

full steam, there is a great loss by back pressure, especially at the end of the stroke, which is almost entirely removed as soon as the quantity of steam used in each stroke is reduced by the "cut off." In the same way, as soon as the "cut off" comes into operation, the initial steam pressure in the cylinder increases, the result being that the area of the sixth stroke, when cutting off all the steam at two-thirds, is larger than when working at full steam.

The practical advantages gained by this improved "cut off" over the former system are:—

1st.—The use of a less quantity of steam.

2nd.—Saving the violent oscillations of the ropes, and so lengthening their duration.

3rd.—Increased safety by the prevention of over-fast winding.

4th.—Increased output owing to the regularity of each winding. In ordinary engines the speed of one winding with another varies greatly, as much as twenty seconds; whilst with the improved "cut off" the speed is always the same.

The CHAIRMAN asked if any gentleman had any inquiry to make of Mr. Daglish by way of further elucidating his paper. They ought all of them to be very much obliged to Mr. Daglish for the trouble he had taken in describing to the members the latest improvements that had been added to that very valuable engine which was almost unique in its powers and application.

Mr. J. A. G. ROSS remarked, that the diagrams indicating the effect of the steam during the first few strokes showed a large amount of throttling on the exhaust side, and he thought that the expansive apparatus might have been applied at first with equal effect.

Mr. DAGLISH said, he had mentioned in the paper that this was a defect in the engine, for although the exhaust ports had been made especially large, they were still not large enough for the great speed at which the engine worked. The average speed of piston during the whole ascent was 340 feet a minute, and when at the fourth stroke the engine was running much quicker. The diagram would show that in the first stroke there was much more pressure on the cylinder to begin with, and much less back pressure than on the fourth, because the engine was then not running so rapidly, and it was just at that point

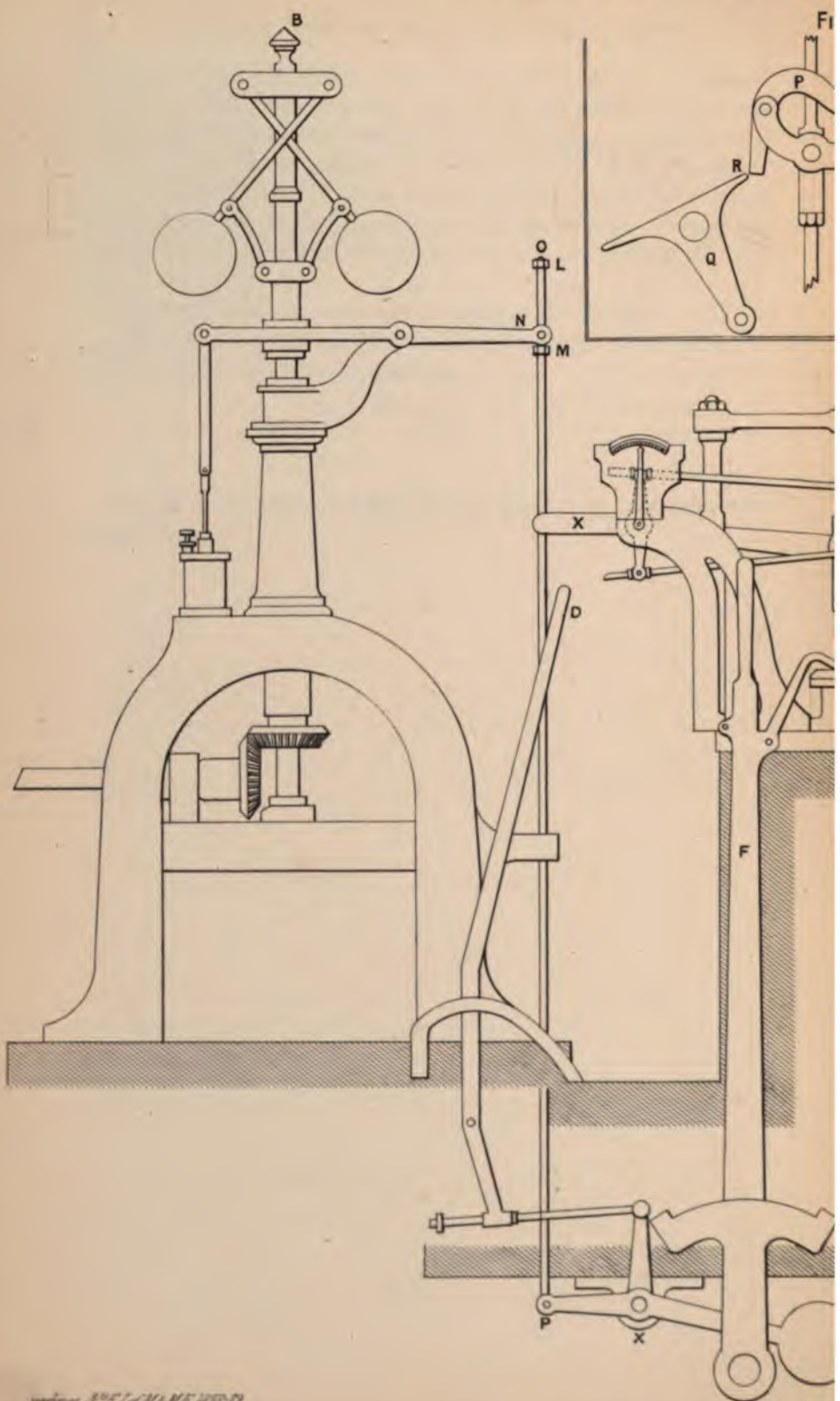
that the governor came into play. The improvement in the lessened oscillation of the ropes was very marked, and was much more than was anticipated; so indeed was the regularity in the time occupied by each ascent. Until he had carefully watched the engine on many occasions unobserved by the engineman, he had no idea that there had been such a difference between the time spent in each lift, but since the governor has been in operation each successive lift is made in almost precisely the same time.

The CHAIRMAN proposed a vote of thanks to Mr. Daglish.

Mr. A. L. STEAVENSON said, he had much pleasure in seconding the vote, which was unanimously accorded.

Mr. W. J. BIRD then read the following paper "On Condensation in Steam Pipes:"—

To illustrate Mr. J. Daglish's paper "On an



Engraved by Mr. E. J. of M.M.M.E. 1878-9

Fig. 3.

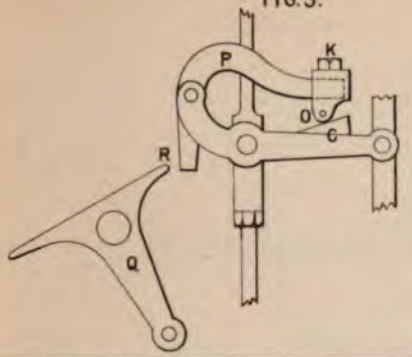


Fig. 4.

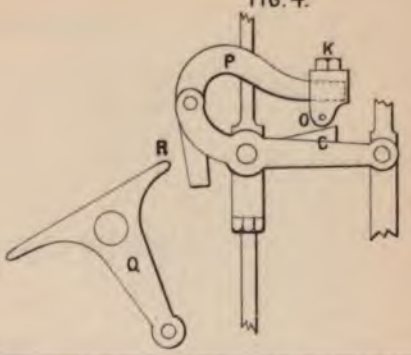
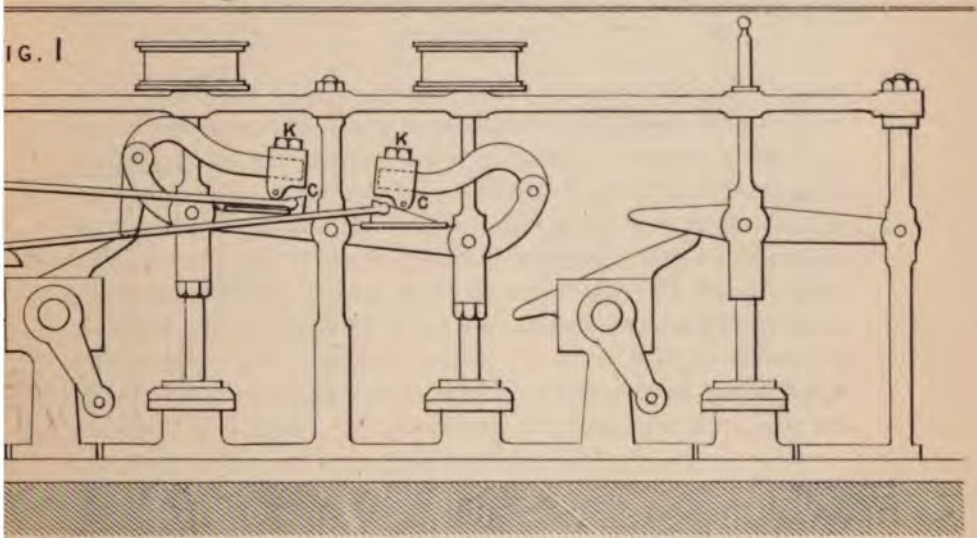


Fig. 1



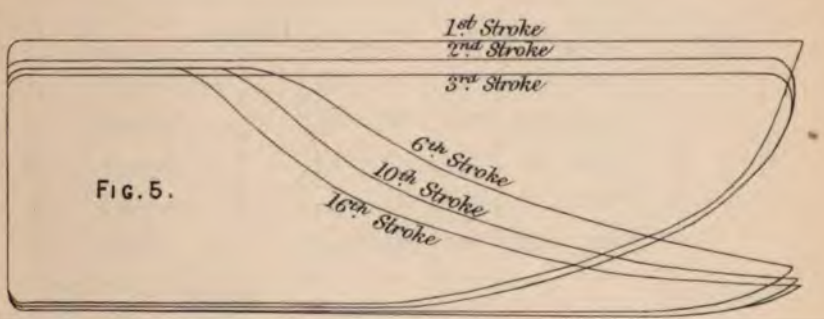


Fig. 5.

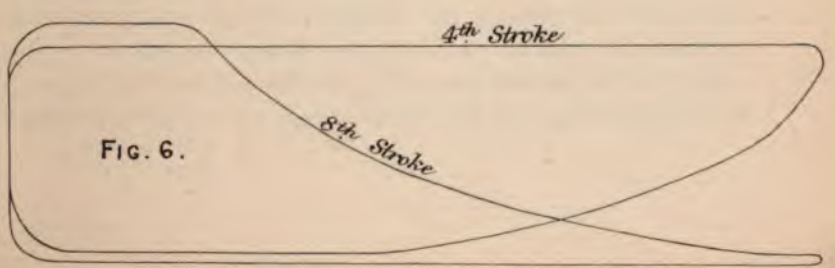


Fig. 6.

CONDENSATION IN STEAM PIPES.

By W. J. BIRD.

It is a well-known fact that, when steam is conveyed a distance through pipes, there is a great loss by condensation; and it is with the view of diminishing this loss that the device of clothing cylinders, boilers, and steam pipes with a non-conducting envelope, has long been practised in the Northern Coal-field. Now-a-days, when steam is supplied from the surface through a great length of pipes to underground engines, the necessity for this clothing becomes of special importance. There are various substances used, of which felt is the most efficient, but sawdust, fir wood, and coal ashes, give very good results. Their comparative efficiency is shown in the accompanying table, in which the diameter of the steam pipe is assumed at 4 inches, its temperature at 212 degrees Fahr., and the temperature of the surrounding air at 60 degrees Fahr.

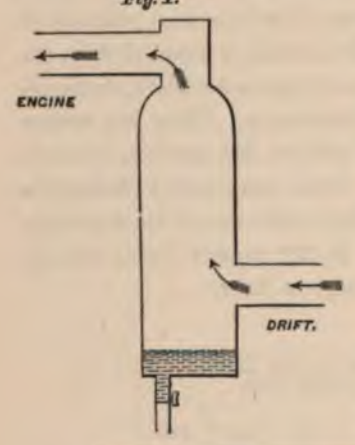
Substances.	Outside Temperature of Envelope in Degs. Fahr.				
Thickness.	½ in.	1 in.	2 in.	4 in.	6 in.
Woollen felt ...	107°	86°	73°	65·9°	63·6°
Sawdust	123°	98°	80°	69·3°	65·7°
Fir wood	137°	110°	87°	73	68·0°
Coal ashes	158°	129°	101°	81	73·4°
Plaster	188°	168°	140°	109	95°

This table shows the effect of increasing the thickness of the non-conducting envelope, but this thickness has an economical limit, independent of the increased cost of material. Take the case of the four-inch pipe encased with two inches of felt. The total diameter will be 8 inches. Supposing it encased with 6 inches of felt, the total diameter will be 16

inches. The surfaces of the pipes will then be in the proportion of 8 to 16, or 1 to 2. With the 2 inches of felt the table shows the outside temperature to be 73 degrees, and with the 6 inches thickness 63·6 degrees. Thus, while 9·4 degrees is gained by the increased thickness, the cooling surface is increased twice, and the gain thus becomes illusory.

At Wingate Colliery, early in 1876, there was erected one of Davey's underground differential pumping engines, which necessitated the use of a great length of steam pipes from the surface. At first these pipes were uncovered, but in a short time they were clothed with a non-conducting composition obtained from Mr. R. B. Lyon, of Newcastle. Its cost was £2 10s. per ton, and one ton was sufficient to clothe ten yards of steam pipe one-and-a-half inches thick. This envelope was coated outside with tar and varnish to keep out wet.

Fig. 1.



A number of experiments were taken to ascertain the amount of water condensed in the pipes, both before and after the covering was put on, and it is to the result of these experiments that the writer invites the attention of the members.

The condensed water was collected in a receiver placed immediately near the engine, Fig. 1, and drawn off at regular intervals, and the rate of condensation was thus obtained with the following results:—

State of Pipes.	Water Collected.			Equivalent of Condensed Water in Steam per Minute.	Steam Consumed by Engine per Min.	Approximate Loss of Steam.
	Time.		Quantity.			
	Mins.	Secs.	Cub. Ft.	Cubic Feet.	Cub. Ft.	Per Cent.
Uncovered ...	42	35	11·286	205	573·8	26·3
Covered ...	25	26	3·818	119·8	706·2	14·5

It was obvious that this result was complicated by the presence of water mechanically brought over from the boilers. It was thus necessary to find some means of ascertaining the proportion of the collected water due to condensation only, and this was effected in the following manner. Observations of the temperature, both of the steam pipes and of the surrounding air were taken at bank, *i.e.*, from the boilers to the upcast shaft; in the

upcast shaft; and in the drift from the shaft to the engine. The following are the dimensions of the steam pipes and the average temperatures observed:—

Section.	Length of Pipes.	External Diameter.		Cooling Area.		Outside Temperature in Degs. Fah.					
		Uncovered.	Covered.	Uncovered.	Covered.	Uncovered.			Covered.		
	Feet.	Inches.	Inches.	Sq. Ft.	Sq. Ft.	Pipe.	Air.	Difference.	Pipe.	Air.	Difference.
Bank ...	81	9½	12½	210	271	251°	46°	205°	92°	61°	31
Shaft ...	618	10	13	1686	2149	251°	66°	185°	97°	67°	30
Drift ...	54	9½	12½	140	181	251°	72°	179°	102°	70°	32

The condensation of water in steam pipes is due to the loss of heat by these pipes, and the heat lost is partly by radiation to surrounding objects and partly by the contact of the pipes with the colder surrounding air. The loss is estimated in units of heat, one unit being the amount necessary to raise one pound of water one degree Fahrenheit in temperature.

In ascertaining the loss by radiation it must be observed that the radiating power of bodies depends on the nature of their radiating surface. This power has been ascertained by experiment for many substances. Let R be the radiating power in units of heat emitted per square foot per hour when the radiating body has an excess of temperature of 1 degree Fahr. For the uncovered steam pipe the value of R is ·69, and for the covered pipe R is ·74 heat units. Now, for ordinary atmospheric temperatures, and for small excesses of temperature in the radiating body, it may be assumed that the heat loss is simply proportional to that excess, but for considerable excesses of temperature the heat loss is much greater, that is, the heat loss increases in a greater ratio than the excess of temperature increases. This ratio has been investigated by Dulong, and by him determined for various temperatures. Now, supposing R to be the heat units emitted per square foot per hour for an excess temperature of 1 degree Fahr.; D the excess of temperature in degrees Fahr. of the radiating body over the absorbent, and r the ratio in which the heat loss increases with the increase of D. Then $R \times D \times r$ is equal to the total loss of heat by radiation in heat units per square foot per hour.

The loss of heat by contact of air is independent of the nature of the surface. Supposing A to represent the heat units lost per square foot per hour for an excess temperature of 1 degree Fahr.; this quantity has been experimentally determined for cylindrical bodies such as pipes; for small

excesses of temperature the heat loss is simply proportional to that excess, but with large excesses of temperature, Dulong has shown that the heat loss increases in a higher ratio, and he has determined this ratio for various temperatures. Thus, let A be the heat units lost per square foot per hour for an excess temperature of 1 degree Fahr.; D the excess of temperature of the pipes over the surrounding air; and r' the ratio of increase of loss; then $A \times D \times r'$ is the total heat loss per square foot surface per hour from contact of air.

Thus $R \times D \times r$ is the heat loss per square foot per hour from radiation, and $A \times D \times r'$ is the loss per square foot per hour from contact of air, and these quantities are added together. The heat units lost per square foot per hour are obtained; and multiplying this by the square feet surface of the steam pipes, the total heat units lost per hour are arrived at. Knowing this, and also the specific and latent heat of the steam in the pipes, it is possible to calculate the amount of steam condensed per minute, and thus arrive at the loss occasioned by such condensation.

Worked out by this method, the particulars of the steam pipes and the observed temperatures give the following results:—

Condition of Pipes.	Loss of Heat in Units per Minute.	Equivalent Steam Condensed per Minute.	Loss of Steam per foot length of Pipe in cubic feet per Hour.	Loss on Steam Consumption.	Loss in Horse Power.
		Cubic Feet.		Per Cent.	
Uncovered ...	11783	79·42	6·59	12·16	10·2
Covered ...	1739	12·08	0·96	1·68	1·5

This shows a remarkable contrast, the loss of steam being reduced from 12·16 per cent., when the pipes were uncovered to 1·68 per cent. with covered pipes. The loss expressed in actual horse power is 10·2 in the first instance, and only 1·5 in the second. This implies a gain of 8·7 horse power, and if the amount of coal burnt is estimated at 5 lbs. per horse power per hour, the saving in fuel is more than nine cwts. per day. If the value of the fuel burnt is taken at 4s. per ton, the saving in coal will be about £35 per annum. The saving in steam is found to be 67 cubic feet per minute, which means that less boiler power will be necessary after the pipes are clothed. This is a very important consideration, for an economy is effected in the first cost of boilers, in their annual deterioration, and in the cleaning and repairs necessary to keep them in good condition.

As the amount of condensed water is known, and also the total amount of water collected in the receiver, the quantity of water mechanically

brought over from the boilers by the steam can easily be determined. The amount of water collected in the receiver was found to be very fluctuating, requiring a large number of trials to obtain a correct average. It was evident that the quantity of the water condensed would be regular, and that the fluctuation was in the water mechanically brought over. This fluctuation was found to be greatest when the boilers were being fed, and was also no doubt due in some measure to irregular firing. Apart from these considerations, the amount of the water brought over would depend on the velocity with which the steam travels in the pipe.

However accurate the process may be by which the loss due to condensation only has been estimated, it would be desirable to have some practical test of the result. There are two methods of obtaining this, but unfortunately neither of them were applicable to the case under consideration.

The first method involves the necessity of two receivers, one near the boilers, and the other near the engine. The first receiver will intercept all the water mechanically brought over from the boilers, and the second receiver will thus collect only the water condensed in the length of steam pipe between the receivers. As there was only one receiver fitted up in the case under notice, the above method could not be used.

The second method does not involve the necessity of two receivers; so long as the temperatures of the steam pipes and of the surrounding air remain constant the condensed water will be deposited at the same unvarying rate. Supposing the engine standing, if the steam is shut off at the engine only, and the pipes and the receiver left in full communication with the boilers, it is evident that the condensed water will be the same in amount as if the engine were going, since it depends solely on the temperatures and not at all on the absolute amount of steam passing through the pipe; for as fast as the condensation consumed the steam, the pipes would be kept supplied from the boilers, and the steam kept up to the same pressure. The steam velocity in the pipe consequent on this movement is so small that practically no water can be brought over mechanically from the boilers. The writer was precluded from adopting this method, since there was a rise in the level of the steam pipe from the bottom of the shaft through the drift to the receiver. This caused the condensed water to collect in the bend instead of coming over into the receiver. But the rise was so small that when the engine was started, the steam velocity in the pipe was amply sufficient to bring over all the water to the receiver.

When there is an uninterrupted fall to the receiver this method will give a satisfactory result, and if any members should be in a position

actually to measure the water condensed in steam pipes by either of these methods, the writer would be glad to receive particulars of such measurements, to compare them with results obtained from the observed temperatures.

In this case there was a loss of pressure of steam due to friction in the pipes equal to 0·4 lbs. per square inch, but this had no effect upon the amount of condensation. The temperature of steam indeed decreases with its pressure, but in this case the decrease was neutralised by the heat developed by the friction of the steam against the pipe, and thus the real temperature of the steam was unaltered, and consequently the condensation remained unaffected.

These observations show a remarkable economy due to the clothing of the steam pipes, so much so that it would be gross waste to allow any length of pipe to remain long uncovered. The envelope has now been on the pipes at Wingate more than three years, and as yet exhibits no deterioration.

When large steam pipes are employed the loss by friction is small, and when clothed the loss by condensation is small, so that steam can be economically conveyed great distances, a fact which no doubt in time will abolish the use of underground boilers to supply the underground engines. This practice often raises the temperature considerably, besides involving some danger from fire. So long as steam pipes are unclothed there is great economy in having the boilers near the engine, but when they are properly covered the loss of heat is insignificant and the difference almost disappears. The employment of compressed air as an engine motor and as a reservoir of power, now attracts much notice. Its advantages are undeniably great, particularly when power has to be applied at a great distance, still it loses pressure by friction as much as steam would do. If, where steam was used, the pipes were suitably clothed, the heat and loss of steam would be so small that compressed air would have but trifling economical advantage over it.

The CHAIRMAN said, they had before them a very interesting paper, for which he was sure they were very much obliged to Mr. Bird. It seemed to him a desideratum which had been long wanting to exactly measure the effect of condensation in pipes. He thought the subject might be extended so as to include an enquiry into the loss of heat, if any, which occurred when compressed air is conveyed long distances in pipes, and also as to the nature of the materials used as non-conductors.

Mr. BIRD said, the material with which they clothed the pipes, in the first instance, was a patent composition, of which they were not supposed to know the details; but his idea was that it was a compound of sawdust, clay, and horse dung, and this composition was still on the pipes; since then, they had had two other compositions introduced to their notice. One, a section of which is shown in the adjoining woodcut (Fig. 2), is made of an inner circle of asbestos, backed with paper A, and two outer circles of compressed paper, B and C, with felt between them E F; the outside of all being well varnished. This was split down one side at G, sprung open, put over the pipe, and secured by means of cement, and a few small dogs H; the other material was simply a mixture with which to coat the pipes, which was supposed to have the advantage of not ultimately cracking or giving way with the action of the heat. They had certainly tested it for a fortnight, where it was partly exposed to the action of exhaust steam impinging on it, and they had found it resist well under these unfavourable circumstances. The cost of the latter composition was about fourpence a square foot, and the cost of the arrangement shown in the woodcut, was tenpence a square foot, but the latter was easily put on, whereas the cheaper composition required a considerable amount of labour to attach it to the pipes.

FIG. 2.

Mr. J. A. G. ROSS said, he would like to ask Mr. Bird if he had not tried a substance which was known by the peculiar name of silicated cotton, or slag wool, patented and manufactured at Middlesbro' by Messrs. Pease, Gilkes, and Co. During the time of the French Exhibition Mr. Semarks had tried some experiments with it, and had stated that it and asbestos had been found to be the two best non-conductors,

and this he readily understood, since the silicated cotton held between its fibres a considerable quantity of air, which being confined with it was probably a better non-conductor than even the silica.

Mr. BIRD said, he had confined his remarks to those linings which had actually come under his own observation. He had heard of silicated cotton, but he had not yet applied it.

The CHAIRMAN said, they were very much obliged to Mr. Bird for the trouble he had taken in giving them the results of his experiments. The paper was very valuable, and would, he hoped, encourage more experiments.

A vote of thanks was then awarded to Mr. Bird, and the meeting terminated.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, OCTOBER 4TH, 1879, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

G. C. GREENWELL, ESQ., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting and reported the proceedings of the Council.

The following gentlemen were elected :—

ORDINARY MEMBER—

Mr. C. ERNEST BELL, Park House, Durham.

ASSOCIATE MEMBER—

Mr. GEORGE TURNBULL, Seaham Colliery, Seaham Harbour.

STUDENTS—

Mr. ALFRED CRAWHALL CHAPMAN, Silksworth Hall, Sunderland.
Mr. HUGH BRAMWELL, Tynemouth.
Mr. WM. C. MURRAY, South Derwent Colliery, Annfield Plain, *via* Lintz Green Station.

The following were nominated for election at the next meeting :—

HONORARY MEMBER -

Mr. G. A. LEBOUR, Professor of Geology, College of Physical Science, Newcastle-upon-Tyne.

STUDENT—

Mr. THOMAS B. MACKINLAY, West Pelton Colliery, Chester-le-Street.

The following paper was read "Notes on Coal Dust Explosions," communicated by Mr. D. P. MORISON :—

NOTES ON COAL DUST EXPLOSIONS, ABSTRACTED FROM THE "ANNALES DES MINES."

A REVIEW OF THE PAPER READ BEFORE THIS INSTITUTE, BY MESSRS. A. FREIRE-MARRECO AND D. P. MORISON, BY M. LOUIS DOMBRE.

COMMUNICATED BY D. P. MORISON.

AFTER reviewing to some extent the important experiments conducted by Mr. Galloway, and published by him in the Transactions of the Royal Society and other periodicals, the author (M. Dombre) examining the theory propounded by Mr. Galloway of the danger of a mixture of coal gas (or fire-damp) and coal dust, proceeds :—

"Messrs. A. Freire-Marreco and D. P. Morison express their opinion that Mr. Galloway's conclusions are too absolute. According to their views *coal dust* should be described. There are *dusts* and *dusts, i.e.*, that of cannel coal differs from that of anthracite. It may be possible, then, that the dust on which Mr. Galloway experimented did not possess the qualities requisite to produce explosion without the presence of an admixture of fire-damp; but the same may or may not apply to other dusts."

"These considerations induced Messrs. Marreco and Morison to extend the scope of the experiments of Mr. Galloway," and the results given in the paper already presented to the Institute are carefully detailed with reproductions of the diagrams and the conclusions to which attention was invited.

M. Dombre, after criticising the table of flames produced by the various samples of dust submitted, concludes his paper by the following remarks, which, proceeding from an impartial judge, should merit attention from the fact of that impartiality, as well as from the interest accruing to his remarks from several analogous cases cited by him:—

"From the experiments which have given rise to this notice, we think that we may be entitled to assert—

"1st.—That a gaseous mixture produced by a shot may, in certain cases, set fire to coal dust held in suspension in the atmosphere of the working places where the shot was fired, and thus produce a *veritable* explosion.

"2nd.—That the nature and composition of the dusts play an important part (*un rôle capital*) in the mode of commencement and in the propagation of such an explosion.

"It is probable that the inflammation of the dust will be (other conditions being equal) more easily effected and further spread by the fact of the coal which produces the dust possessing a larger proportion of volatile matter.

"We must now ascertain how far such an explosion will be localised, embracing a district more or less surrounding its origin, or whether it may under certain circumstances spread through the mine, and thus become the cause of catastrophes such as those of Pelton, of the pit 'Cing Sols' of Llan, of Tabin, or of Blantyre.

"This question is one which the results of experiments, however ingeniously conducted, can scarcely elucidate, and its solution may perhaps for ever be only a theoretical induction.

"It now appears undeniable that in the presence of fire-damp, even in minute proportion, the explosion, at first local, spreads with rapidity, and may even assume suddenly alarming proportions. But if no fire-damp exists in the workings where the explosion originates, and if none is to be found in the neighbouring workings, is it to be supposed that the gases evolved by this more or less complete carbonisation of the dust alone, are sufficient of themselves to sustain combustion, propagating it and permitting it to feed itself by alimentation from distant districts of the mine?"

In a foot note M. Dombre mentions that, in the explosion of the Javin pit, coke was found in the timbering nearly $1\frac{1}{8}$ inch. in thickness, and that the analysis of this coked dust proved that 25 per cent. of volatile matter had been lost between the states of dust and of coke; or, in other words, that every kilogramme of dust had given off in weight 70 grammes of inflammable gas, say 7 per cent., quite enough to account for the most disastrous effects of heat and after-damp which have yet been experienced.

Blantyre, Swaithe-Main, Pelton, and too many other local sweeping catastrophes point to the dire effects of dust explosions as exhibited by the coking and charring of bodies, timbers, the sides or roofs of galleries, at points far distant from any possible reach of gas *per se;* and here it may be asked whether any heavy *wide spread* explosion has been observed and noted in a seam sufficiently damp to prevent accumulations of dust in the working places or main roads.

M. Dombre after some instructive remarks in criticism of the theory that excess of ventilating force may intensify explosions, and after particularising the support given by M. Chausselle to this idea, thus potently expresses himself:—

"Although to some slight extent sharing these views, we may observe that in our opinion improvements in ventilation do not constitute the primordial cause of this tendency of local explosions to develope into catastrophes, but that the fault lies in the increased *area* of the workings themselves and in the large number of men working in one district and in one current of air (this appears to apply specially to the *long wall*), or more plainly in the undue concentration of the working places."

He then adds that increased ventilation has had to follow the necessity created by this increase of face and workers, and continues:—"Speaking of what he terms the 'paradox' of M. Chausselle, Mr. Galloway recommends the use of water for laying the dust in workings where powder is used: 'In future,' he says, 'in addition to the old cry of *air, more air*, we must add a new one easily supplied, *more water*.' Mr. Galloway perhaps overrates the possibility of applying in practice the remedy he proposes. If the employment of water is practically possible in English mines, the same does not hold good on the Continent, where the seams are lying at heavy inclinations and under very different conditions of stratifications.

"Is it not better to cut at the root of the evil, by requiring from the mechanic a tool simple and handy, suppressing and superseding gunpowder or other igniting mediums in dry and dusty workings?"

The subject of coal dust and its influence in colliery explosions having now been taken in hand by an influential and practical committee appointed by the Chesterfield and Derbyshire Institute of Engineers, well provided with the sinews of war, some further light may be thrown on the almost unknown influences of dust, heat, and draught in *colliery disasters*.

The following circular has been issued by the Council of the Chesterfield and Derbyshire Institute of Mining Engineers:—

The question as to the effects of coal dust aggravating, and even being in some cases the cause of, colliery explosions, has lately formed the material of a communication to this Institute, and the investigation of the subject has subsequently been continued and the results embodied in a paper read before the North of England Institute of Mining Engineers.

In view of the importance of the subject in relation to the safety of life and property, it has been arranged to institute a series of experiments on the coal dust of this and other districts, in order to make a comparison with previous tests, and if possible to elicit still further information upon so important a subject.

In order to carry out such experiments, there will have to be a certain outlay upon the necessary apparatus and instruments, and it is estimated that a sum of £50 will be required for properly carrying out the work.

The Council of the Institute have voted the sum of £10, and the sub-committee have thought it desirable to lay the question before the members of the Institute and others, with a view of getting their co-operation.

The PRESIDENT said, he was sure the members were very much obliged to Mr. Morison for having brought before them observations on this important subject which had been made by a gentleman so competent as Mons. Dombre. They would also arrive at a unanimous conclusion that the question is still one that requires careful consideration from all those who have opportunities of investigating it. The members had had placed before them the different conditions which existed in dry and wet mines. Most of them had the opportunity of making such comparisons, but he was glad to say that the engineers in this district had most fortunately for some years past been relieved from the necessity of much personal investigation into such matters. However, it was impossible to foresee what might happen, and the better prepared all were to meet every contingency that might arise the less chance of accident would exist, and therefore it would be well if they considered carefully those points which had been touched upon in the extract which had been read by Mr. Morison, and he was sure he could not leave it in the hands of better or more able gentlemen than those he saw before him to further inquire into the matter.

Professor LEBOUR desired to call the attention of the members to a paper by Professor Peek—an American scientific man. The paper, which was published in the current number of the "Monthly Journal of Science," gave details of certain experiments which Professor Peek had made with flour dust. In most cases these experiments show the very explosive nature of this dust, and they undoubtedly bore on the subject in hand.

It was then understood that Mr. Morison would kindly make an abstract of the paper referred to by Mr. Lebour, but afterwards Mr. Morison explained that at present it might be advisable to wait for the experiments which the Chesterfield and Derbyshire Institute were organizing. They intended to investigate the question in a much more detailed manner than Professor Marreco and himself had done, and they were constructing a test-box which he hoped might give explosions without personal danger to the experimenters, but which would be sufficiently large to represent what might occur down a drift, everything being in

proper proportion. They wished to experiment, not only on different dusts as did the North of England Institute, but to gauge exactly the proportions of dust per cubic foot of air, to follow out Mr. Galloway's experiments, and to test every proportion, however minute, of fire-damp or coal gas (both at their disposal); they intended also to vary the temperature of the air in every experiment, by means of pipes heated by steam, and to imitate the disturbing influences of horses, men, and falls of coal, by means of agitators placed in the box. They further contemplated testing the force of the explosion, apart from the damage caused by the flame, this having been found to be very disastrous in many collieries, and to ascertain how far the ignition of coal dust will blow doors open, by placing imitation regulators proportionate to the size of the box; and he thought that after these experiments were completed they might reproduce their own as well as those of the Chesterfield Institute, and perhaps even subsequent experiments.

Mr. E. F. Boyd asked, if there was any understanding between the Chesterfield Institute and their own as to the communication of papers?

Mr. Morison said, there was none whatever except that he was a member, and on the Coal Dust Committee of both.

Mr. Boyd asked, if there was any understanding by which the Chesterfield Institute would favour the North of England Institute with results of their experiments?

Mr. Morison said he was sure they would, because so far the two Institutes had assisted each other in every way, and that the two Institutes had really worked to some extent together. He further stated, that as Professor Marreco and himself were both on the committee appointed by the Chesterfield Institute, if it was the pleasure of the meeting he could communicate with the Secretary of the Chesterfield Institute on the subject.

Mr. D. P. Morison then read the following paper "On Boiler Accidents and their Prevention:"—

ON BOILER ACCIDENTS AND THEIR PREVENTION.

By D. P. MORISON.

PART II.

In resuming this important subject, which by a few introductory notes was already prefaced in a recent contribution by the author, it is intended to amplify to some extent the figures and statistics derived from home and foreign compilations. It is also the object of the writer to classify, as far as possible, the uses, construction, and efficiency of the various societies, or other schemes for preventing or alleviating the disasters which attend the employment of steam generators or boilers, and, as far as practicable, to trace their causes, and possibly to suggest means for their prevention.

It may therefore be in the first instance interesting to supplement the figures given in the Introductory Notes (Vol. XXVIII., p. 249, etc.) by the tables (see Appendix), which bring up the statistics of our home boilers to the end of last year: Table I. being a summary of the causes of explosion; Table II. a summary of the construction of the boilers; and Table III. a summary of the uses to which the boilers were put.

The statistics have been still further amplified in Table IV., which may be taken as a general summary of all the particulars collected from the various returns of companies, as well as of the Board of Trade Inspectors, and will, by the mode in which the figures are tabulated, exhibit the various divisions of the previous statistical separation.

Having now given in detail the results obtained from the data of the last ten years observations, it may be useful to form some general conclusions which will inevitably occur from the study of the figures so tabulated.

It is estimated that there are 200,000 boilers in the United Kingdom, but, as previously mentioned, this is mere conjecture, and is probably an under statement. As all the deductions as to the number of explosions in proportion to the boilers used depends on correct estimate, it would be

useful, as a first step towards correct enumeration, if the Government itself would take up the matter and institute a boiler "census" (if the term be applicable) for boilers, to ascertain the boilers in use.

They should be classified—

1.—Marine.
2.—Locomotive.
3.—Portable.
4.—Stationary.

The first three classes are nearly all internally fired, but the fourth class might usefully be divided into those *(a)* internally, and *(b)* externally fired, and further divided into the various types most in use.

These figures could be obtained through the Inspectors of Coal Mines, the Factory Inspectors, and the Railway and Marine Department of the Board of Trade. They would form good data as to the work to be done if all boilers have to be inspected by authority.

At the present moment many boilers are under the care of Companies having for their objects the inspection or insurance of boilers intrusted to them. In some cases additional precautions are solely intended, while in others compensation for damages is also guaranteed.

The number of boilers under the care of the different Companies, and their mode of inspecting and assuring, may now be introduced.

The "Steam Users' Association" was the first formed for inspection only, at about 13s. per annum per boiler. This did not provide the owner with enough security that the work undertaken would be efficiently done, and a new Company was created to add assurance as a further guarantee, as well as compensation for the pecuniary risk involved, which afterwards became the "Steam Power Company." The "National" is upon the same principle, but encourages what it considers improved fittings by charging less where certain plugs are used.

The "Midland" was formed by iron and coal masters for the protection of their boilers, as the other companies, with their head-quarters in Manchester, did not appear willing to undertake the inspection of hard-worked boilers in iron works and coal mines, especially where heated by waste gases from furnaces. It was intended at first only as an Inspection Association, but Assurance was added, as generally preferred by boiler owners.

The "Yorkshire," the "Mutual," the "London Mutual," and the "Newcastle," are on the same principles as the other assurance companies.

The "Engine and Boiler Company" is comparatively new, but includes the engine for inspection and assurance.

Much discussion has arisen on the subject of Assurance as applied to boilers, under the impression that it was not so legitimate an object as many other risks, such as those by fire or wreck.

The "Steam Users' Association" denounce it as the source of much evil, as it makes Assurance Companies eager for business and profit, and thus neglect inspection, and in consequence they have organised a system of guarantee by which damage is paid in case of failure of a boiler up to £300 for an annual payment of £1 11s. 6d. The guarantee fund was at first made by ten volunteers being responsible for £1,000 each, but it is gradually being replaced by accumulated overplus. No profits are divided, but any overplus is spent on scientific experiment.

The Assurance or Insurance Companies provide guarantee funds like any other joint-stock company by unpaid capital and reserve funds saved from profits, and they assert that it is a more business-like and fair way than trusting to volunteer aid. Also, that there is no more reason to doubt that such business will be done well because a profit is made than that railway companies, or any other trading companies, will not do their business to the best of their ability to maintain their reputation.

There is perhaps little difference between ordinary assurance and the system of guarantee; but the real point is, whether either of these, or inspection alone, insures the greater care being taken of the boilers?

The chief expense of all the Associations and Companies is the inspection, as a rule, four times a year of each boiler, and therefore anything that tempts to the slighting of that work is to be feared.

The "Steam Power Company" have carefully compared results of inspection and assurance, but the figures are not open to testing. The result is said to be that the number of casualties and explosions have been less among assured than inspected boilers. Other companies have asserted the same thing, but complete statistics are not easily obtained.

The work of the "Midland Company" has been among the heaviest worked boilers of the kingdom, as in many iron works the power required is so great that they are composed of little else than boilers; and until lately it was thought necessary that these should be close to the furnaces and mills, and of course amongst the men. Considering the great frequency and fatality of boiler explosions among these more complicated boilers, the number of explosions has diminished in as great a proportion as in the case of the more easily-managed ordinary mill boilers.

The following notes on our British ideas of inspection, inquests, and Government superintendence, will pave the way to a more complete investi-

gation of the entire subject; and the writer finds that the more the depths of foreign reports are explored the more the subject becomes extended, and the more the interest accrues. It is, however, the intention of the writer to condense, as far as possible, in the present series of papers, the enormous mass of statistics placed at his disposal, so that the practical questions of boiler building, setting and maintenance, may follow rapidly on these preliminary notices.

INSPECTION.

The highest perfection which could be devised for boilers would be (1) undoubted scientific and safe form, (2) best materials and workmanship, (3) good mountings and well-regulated fittings, (4) attention by experienced men fully capable of making a thorough and competent inspection of every part at short intervals, and (5) that those in charge should take such pride and interest in their work as never to neglect an opportunity of such inspection.

It has been the ambition of most of the associations to lead up to such a model, but in practice there are many difficulties in the way, and the vast majority of boilers work under very inferior conditions.

In the first place the forms of boilers differ in a great measure from fancy or the convenience of the work, and *safety* is only one out of many considerations in making choice. The most suitable material and modes of manufacture and proportion of seams and rivets are still matters of conflict and of opinion. The mountings also may be either as much self-acting as possible or subject to constant control; and each class has its strong advocates, as in the one case the attendant is lulled into supposed security by the self-acting fittings, and in the other is liable to accident by any slight neglect on his part.

The exigencies of modern work demand more division of labour than wasting the time of one able to inspect on ordinary firing; and last, not least, the attendant is apt to be influenced by the desire to keep the works going and to postpone the day of inspection. Also, the limited experience of an ordinary boiler attendant does not usually equal that of an inspector appointed for the sole purpose of inspection, and with wide experience of all classes of boilers and a good study of many instances of mishaps from which to form a right judgment as to the best means to avert casualties.

The whole matter becomes one of sound judgment, and experience tells for much, especially in collieries, factories, iron works, and similar outlying places.

INQUESTS.

The Coroner's Inquest is such an ancient and useful institution that it is perhaps well to leave its investigations as to those killed by boiler explosions, without burdening the juries to add any scientific reasons for the explosion, in which they can only reflect the opinions most strongly put before them by interested or other technical witnesses.

It would be convenient, however, if the records of explosions could be obtained with more certainty than by the private efforts of the Companies.

Without some distinct and recognised authority the majority of cases cannot be properly investigated; and, as a step towards a boiler "census," a record of explosions, with a short account of the effect and cause of each, either from special reports or compiled from the reports furnished to the coroner, would be useful if published in such a form as to be fairly intelligible to the working men in charge. For this purpose perspective sketches are useful in preference to scientific line drawings or long tedious descriptions.

Such reports and descriptions as are given of railway accidents and of locomotive explosions of the Railway Department of the Board of Trade would amply suffice, and be of material assistance to coroners, juries, witnesses, inspectors, and that portion of the public supposed to be interested in the enquiries.

GOVERNMENT INSPECTION.

It has been well said that sad as the loss of life by boiler explosions may be, the remedy of Government inspection is not so certain as to warrant the cost of the army of inspectors needed to do the work thoroughly; and that the best course is by all means to foster the willingness of owners to undertake the arrangement for inspection for themselves or through Associations or Companies.

There is a misapprehension as to the Government inspection of marine boilers. The Board of Trade provide for inspection of boilers in passenger vessels and grant a certificate, but it is optional whether owners have it or not: but they generally do, as it assists them in case of mishap.

It is considered by many that even if the Government are forced to take the matter up it would be sufficient to say that all boilers must be inspected by some one, leaving the owner to select, and to be responsible for the selection of the Inspection Company thought most likely to be efficient at a moderate cost.

Inspection would then be a fair and useful employment either for individuals or companies, and if all owners were bound to provide for

having each boiler seen inside and outside twice a year at least, a great part of the difficulty would vanish.

The figures already given of boiler accidents and their attendant loss to life and limb may now be advantageously compared with the statistics of railway accidents, where effects and causes are understood to be under the control of, and investigated by, the Board of Trade, *i.e.*, Government inspection. These are illustrated by Tables V. and VI.

We now come to the results obtained by the German, French, and other foreign associations for the independent inspection of boilers, which are most carefully and minutely detailed in Tables VII. to XV., in the Appendix. These tables most plainly indicate the growing anxiety on the Continent for auxiliary inspection, and the care bestowed on the transactions and reports of the various societies compares favourably even with the best of our own Companies.

The following extracts and abstracts from the reports of a few of the societies furnishing the tabulated statistics will be read with interest.

FOREIGN INSPECTION ASSOCIATIONS.

I.—FRENCH AND BELGIAN.

ASSOCIATION POUR LA SURVEILLANCE DES CHAUDIERES, BRUSSELS.

(Boiler Inspection Association.)

1,740 boilers were inspected under this Company in the year ending 1st January, 1878. No explosion has occurred since the formation of the Association. The annual inspection reports for the year 1877 constitute a most instructive volume, of about 350 pages, with drawings, tables, &c.

The members of the Institute will hail with satisfaction the announcement that in the Board of Management the names occur of two of their own body, M. Gnibal and M. Guinotte, one an honorary and the other an original member.

The report is noticeable by many most suggestive, although, perhaps, rather self-laudatory remarks, *e.g.*:—"The aim of this Association is realized, and we have proved by our own example that all explosions may be prevented by a relatively inexpensive inspection. * * From ordinary probabilities, if our Association had not existed and our inspection had not been well managed, five boilers, at least, would have exploded (*Sauté*).

"You (*i.e.*, the members of the Association) are aware that the greater safety which your boilers enjoy is not due to repairs being more frequent. On the contrary, thanks to the reports and examinations of our staff, we

have managed in most cases to prevent deterioration, and thus to avoid at once repairs and accidents.

"During 1877 our staff made 1,641 internal inspections, and 4,098 external examinations, entailing 894 visits of inspectors and 632 of sub-inspectors."

The cost of inspection per boiler was 20s. in 1875, 18s. 6d. in 1876, and 17s. in 1877.

ASSOCIATION PARISIENNE DES PROPRIETAIRES D'APPAREILS A VAPEUR.

(Association of Steam Power Owners, Paris.)

In February, 1877, this Association numbered 53 members, possessing 148 boilers.

In the report of the engineer, the following are samples of the mode in which the principal defects are signalised :—

47 steam gauges were defective, of which 18 gave erroneous readings due to the absence of a proper bend in the pipe between the boiler and the gauge.

Floats in which a rod works through stuffed glands are condemned.

Safety valves.—Firemen are recommended to keep the point of the lever perfectly clean, and to test its working frequently.

The damper chains are recommended to be brought round to the fire-holes.

The subject of corrosion from leakages is also dealt with at some length, and, finally, a code of instructions to stokers is recommended to be distributed to each fireman employed at the boilers under the Association, of which the following short extract will give some idea :—

INSTRUCTIONS

On usual precautionary measures to be observed in the use of Steam Boilers.

GENERAL OBSERVATIONS.

1.—The surroundings of boilers, fireholes, etc., must always be kept clean.

2.—No admittance of strangers to the boiler house, which must be kept locked during off-time. The fireman never to leave his post until replaced.

3.—Any imperfection observed in the boilers or connections to be immediately reported by the fireman to the engineer.

FIRING.

4.—The fireman, on his arrival, must verify the level of water in the boiler. If this be correct he will light up, or when the fire has been damped down, open, first the damper, secondly, the ash-doors, and lastly, the fire-door. He must then clean his fire and gradually fire up.

5.—Once fired up, the stoker must, every 10 or 15 minutes, throw on small quantities of coal so as equally to cover each portion of the grate. The lumps to be broken into pieces not exceeding the size of the fist, and, in ordinary grates, the thickness of combustible must not exceed 5 inches of coal or 10 inches of coke. Each time the door is opened for firing the damper must be partly closed. A small quantity of water to be kept in the ash-pit.

6.—When the grate, examined from below, ceases to appear free, he must cleanse it half at once, removing the combustible from side to side. In cleaning he must shut down the damper, taking advantage of a time when pressure may decrease.

7.—The stoker must open the damper sufficiently only to obtain the required pressure. If the safety valves blow he must lower the damper without opening the fire-doors.

8.—Half-an-hour before closing time the fire must be slackened; and when time is up the fireman must cover the fire-grate with ashes or damp slack, and then shut in turn, first the damper, secondly the fire-door, and thirdly the ash-pit door.

II.—GERMAN, &c.

MÄRKESCHER BOILER INSPECTION SOCIETY.

The Society had at the end of 1877, 422 boilers. The number of inspections were 1040, of which

622 were external inspection.
316 „ internal „
102 „ Hydraulic pressure tests.

The Engineer in his report had 678 faults to find in his inspection which are classified as follows:—

1.—Defective mountings ... ... 65 cases,
of which there were 13 defective water gauges.
9 „ pressure „
5 „ safety „
2.—Faults from imperfect attendance 293

3.—Faults in boiler plates and setting 166
of which 31 cases were rivet-hole rents.
31 „ were bulging and rents in plate over or near fire.
37 „ of defective setting.

4.—Faults in construction and laying down. These faults are again classified under five heads as follows:—

1.—No. of faults.
2.—Pressure of boiler (working).
3.—Age of boiler.
4.—Construction of boiler.
5.—Method of firing.

The Engineer complains very much of the state of the cocks, fittings, &c., in many places, many of them leak and many are fast. The overloading of safety valves was another source of complaint. Cases of pressure gauges being wrong, many being stopped up with dirt. Spring pressure gauges should be protected from heat, steam, wet, and frost.

The safety valves in five cases were found to stick. The boilers in twelve cases were examined with hammers that were too sharp.

THE SWISS BOILER OWNERS' ASSOCIATION.

At the end of the year 1877 this Association had 1,182 boilers under its inspection.

The following important official notice is worthy of attention:—

THE GOVERNMENT,

Having had under consideration a proposition from the magistrature and the police authorities,

DECREES:

1.—That the laying down and working of all boilers shall be under the inspection of the district police, who will, through their engineer, carry out this order.

2.—That in laying down boilers the first consideration shall be solidity, so far as regards material and construction, for the purpose of insuring its safety and its proper working as well as its connections, all precautions being taken as understood by the *technical world* to make its situation safe and innocuous and its surroundings also secure from explosion and fire, and otherwise to keep it free from damage or molestation.

3.—That before a boiler starts work notice shall be given to the district police, who, by inspection and trials, shall see that the above measures of precaution have been carried out.

Should the inspection and trials not be satisfactory, the working of the boiler shall be prohibited.

4.—All working boilers shall be liable to periodical inspection at least twice per annum.

5.—These inspections shall be—

1.—External.

2.—Internal and external together.

Each of which shall at least be done once yearly.

The external examinations shall be directed to the exposed portions of the boiler furnace and boiler mountings, and shall be only effected when the boiler is at work. The engineer at the same time to see how the stoker peforms his special duty.

The internal and external examination shall consist of detailed internal and external examinations of all parts of the boiler and flues, especially those parts that have been found defective during the examination of the boilers while at work.

In the case of internal examination every preparation must be made, so that on the arrival of the inspector the boiler shall be emptied, cooled, and the flues and other parts of the boiler cleaned and freed from rust.

The entire inspection shall be mutually arranged between the boiler owners and the inspector.

6.—In the case of boilers under the Swiss Boiler Inspectors Association, any inspection made by the engineer of the Association will be taken as sufficient for the above purposes.

In the case of boilers which are not under the inspection of the Swiss Association, the owners of it then shall have the option of having them inspected either by the Swiss Association or by other engineers. In either case notice must be given to the Board of Justices or to the police by those undertaking the inspection.

In cases where the inspection is made by engineers not belonging to the Association, their inspection shall be laid before the Board of Justices or the police who shall decide whether such inspection shall or shall not be taken as correct.

Should a boiler owner not specify the inspection under which his boiler shall be placed, the police will then take such inspection into their own hands.

7.—The expense of inspection shall be defrayed by the owner of the boiler.

8.—The results of all inspections shall be communicated to the police and the owners of the boiler.

Should these results not be found satisfactory a further inspection shall be made, at the instance either of the owner or of the police, but at the expense of the owner.

9.—Should any boiler owner not follow the law laid down in this decree, he shall, notwithstanding any loss or damage which he may thus incur through explosion or any casualty, be liable to a fine of 500 francs, and be further liable to be summoned before the magistrates for not carrying out the decree of the Government.

10.—The Board of Justices and the police are directed, etc., etc., Zurich.

SILESIAN BOILER INSPECTION SOCIETY.

This Society at the end of the year 1877 had 672 boilers under its inspection.

In the Engineer's report for the year 1877 the attention of the steam users was directed to the following faults which seem to prevail:—

Safety valves should have water pipes attached to allow the waste water to escape when lifting the valves during trial, and thus prevent it from filling the interstices between the boiler and the brickwork.

The sludge cock should be fitted close to the boiler instead of at the end of a pipe.

Safety valves sticking fast. Valves with conical bearing surfaces have a tendency to stick. The bearing surface should be straight, horizontal, and small.

Test cocks have a tendency to fasten, owing to leakage.

Only one explosion occurred in 1877 amongst the boilers insured by this Society.

NORTH GERMAN BOILER INSPECTION SOCIETY.

The Society had in 1877 under its inspection 662 boilers. No explosion took place amongst the boilers under their inspection during the year 1877. Among the boilers under their inspection, there were 212 cases in which faults were detected, and these were classed under five heads, viz.:—

	Cases.
1.—Defects in erection	7
2.—Defective materials of boilers—	
(a.)—Not safe—present	16
(b.)—Not safe—future	111*
3.—Defective mountings	5
4.—Imperfect working of the boilers	56
5.—Other causes	17
	212

* *i.e.*, cases where defects (unless remedied) may increase.

Attached to their Annual Report is the receipt for a grease to be used on test cocks to make them water and steam tight, the composition of which is as follows:—Half a pound of tallow, a quarter of a pound of wax, and a quarter of a pound of gutta-percha, which when melted together forms the grease.

THE BAVARIAN BOILER INSPECTION SOCIETY.

This Society had at the end of the year 1877, 1,301 boilers under its inspection.

The Engineer in his report classifies the defects occurring under his inspection as follows:—

	Cases.
1.—Defective boiler mountings and connections ...	293
2.—Defective boiler attendance	327
3.—Dangerous condition of boilers and brickwork setting	396
4.—Faults construction of boilers and boiler seat ...	355

To prevent the corrosion in boilers from acids which exist in oils, &c., the engineer suggests a test of a chemical nature to be applied to oils which will prove the existence of acids if present.

No explosion has occurred within the last five years among the boilers under the inspection of the above Society.

The objects aimed at by the Society are:—(1.) Increased safety in working boilers through prevention of explosions as far as possible; (2.) Economy in the use and raising of steam; (3.) Increase of duration of boilers with minimum cost of repairs; (4.) Advice on the construction and laying down of boilers; (5.) Guaranteed official competence of the Society's engineer; (6.) All trials and inspections carried out in accord- with Government regulations.

It is further stated in the report of the Society that hydraulic tests serve only to support internal examinations, which are the only means of ascertaining the conditions and the safety of boilers.

Internal examination consists in inspecting and examining the boiler and its flues by entering the boiler and traversing the flues.

All parts of the boiler should be properly examined, because it is possible that each *per se* may be defective.

THE SAXONY BOILER INSPECTION SOCIETY.

This Society in 1877 had 640 boilers under its inspection. It is in connection with the Boiler Inspection Society's Union, to which 26 Societies belong, inspecting a total of 17,432 boilers.

During the year 1877 the engineer made 1,790 inspections of the 640 boilers in his charge, of which 1,290 were external examinations, 362 internal examinations, and 138 pressure tests; and, as a result of these inspections, 573 defects were detected.

These defects are classified as follows:—

1.—External examinations.
 (a.)—Mountings.
 (b.)—Working of the boilers.
 (c.)—Brickwork or setting.
2.—Exposed by internal examination.
 (a.)—Construction.
 (b.)—Plates and seams.
 (c.)—Workmanship.
 (d.)—Imperfect cleaning.
3.—Faults exposed by pressure tests.

The most prevalent faults exist in pressure gauges and insufficiency of water gauges in each boiler, two being required, their errors amounting to 130. The engineer in his report states that unfortunately the safety valves are tampered with in many places and too little care is taken to keep the water level in the boilers at its proper height.

No explosion has occurred among the boilers of the Society.

The considerations and conclusions to be drawn from these statistics and reports are intended to be reviewed by the writer in his next contribution, before proceeding to the questions of boiler seatings and boiler materials.

APPENDIX.

TABLE I.

BOILER EXPLOSIONS, 1869 TO 1878.—SUMMARY OF THE CAUSES OF EXPLOSION.

	No. of Boilers Exploded.	No. of Persons Killed.	No. of Persons Injured.
(A).—Faults in construction or repairs	183	205	370
(B).—Faults which could be detected by periodical examination	178	206	401
(C).—Faults which could be prevented by careful attendants	245	288	420
Extraneous or uncertain causes ...	24	7	28
Total	630	706	1219

TABLE II.

BOILER EXPLOSIONS, 1869 TO 1878.—CLASSIFIED ACCORDING TO KIND.

	No. of Boilers Exploded.	No. of Persons Killed.	No. of Persons Injured.
Cornish and Lancashire	214	254	390
Plain cylinder	141	122	341
Marine	48	122	95
Locomotive and portable multitubular	60	50	95
Tubulous (all tubes)	22	19	11
Furnace	19	49	85
Vertical or crane	34	32	66
Balloon, wagon, and breeches tube	23	10	39
Domestic and heating	29	15	23
Rag, kiers, and stills	27	29	52
Economisers, &c.	11	4	18
Not classified	2	..	4
Total	630	706	1219

TABLE III.

THE BOILERS THAT EXPLODED IN THE YEARS 1869–78 WERE USED FOR THE FOLLOWING PURPOSES.

	No. of Boilers Exploded.	No. of Persons Killed.	No. of Persons Injured.
Collieries and mines	131	92	204
Ironworks	122	175	355
Mills of various kinds	70	75	134
Marine	55	127	102
Railway	35	18	45
Agricultural	22	20	26
Chemical	39	33	48
Sawing, turning, building, and glass	29	38	83
Brickworks	19	26	60
Paper mills	23	32	43
Flour mills	22	21	18
Brewing and malt mills	7	9	14
Cranes	5	5	3
Hauling and pressing	5	16	40
Pumping	5	3	2
Domestic or heating	31	15	26
Unknown	10	1	16
Total	630	706	1219

TABLE IV.

DETAILS OF EXPLOSIONS.

THE EXPLODED BOILERS IN THE TEN YEARS, 1869–1878 (INCLUSIVE) WERE OF THE FOLLOWING DESCRIPTION.

THE CAUSES ARE ARRANGED AS IN THE SUMMARY UNDER HEADS A, B, AND C.

CORNISH AND LANCASHIRE.	No. of Boilers Exploded.	No. of Persons Killed.	No. of Persons Injured.
(A).—Bad construction, weak tubes or chambers, want of stays, bad manlids, bad repair	64	81	120
(B).—External and internal corrosion	73	90	161
(C).—Shortness of water, undue pressure, deposit, fires forced too quickly, manlids opened too soon, carelessness with valves or pipes	77	83	109
	214	254	390
PLAIN CYLINDERS.			
(A).—Bad construction or material, seam rip, bad repair, or bad manholes	57	49	128
(B).—External or internal corrosion	41	46	132
(C).—Shortness of water, deposit, undue pressure, carelessness with valves, or fall of steam pipes...	41	26	81
Not ascertained	2	1	..
	141	122	341

Marine.	No. of Boilers Exploded.	No. of Persons Killed.	No. of Persons Injured.
(A).—Bad construction or material, want of stays, bad repair or weak tubes	10	18	8
(B).—External or internal corrosion, or both	16	15	27
(C).—Shortness of water, undue pressure, deposit, manholes or valves insecure	19	86	60
Not ascertained	3	3	..
	48	122	95
Locomotive or Multitubular.			
(A).—Bad construction or material, stays giving way, want of stays, bad valves or manholes ...	18	13	24
(B).—External or internal corrosion	23	22	37
(C).—Undue pressure, or shortness of water	13	14	28
Extraneous, or not ascertained ...	6	1	6
	60	50	95
Tubulous (all Tubes).			
(A).—Bad construction, tubes or joint	8	9	4
(B).—External corrosion	1	1	..
(C).—Scale or mud, overheating, undue pressure, shortness of water, steam pipes insecure... ...	13	9	7
	22	19	11
Furnace Boilers.			
(A).—Seam rip or weak tubes	2	17	49
(B).—External or internal corrosion	6	24	23
(C).—Shortness of water, undue pressure, or deposit ...	11	8	13
	19	49	85
Vertical or Crane.			
(A).—Imperfect weld, bad construction or repair, want of stays, or weak manhole	8	3	13
(B).—External or internal corrosion	6	5	6
(C).—Shortness of water, undue pressure, or overheating	18	24	47
Extraneous, or not ascertained ...	2	..	..
	34	32	66
Balloon, Wagon, or Breeches Tubes.			
(A).—Flaw in material	1	2	2
(B).—External corrosion	10	1	10
(C).—Undue pressure, or shortness of water	12	7	27
	23	10	39

	No. of Boilers Exploded.	No. of Persons Killed.	No. of Persons Injured.
DOMESTIC, SADDLE, OR HEATING.			
(A).—Imperfect weld, or weak shape	3	1	1
(B).—External corrosion	1	..	5
(C).—Undue pressure	25	14	17
	29	15	23
RAG, KIERS, OR STILLS.			
(A).—Bad construction or manholes	12	12	21
(B).—Internal corrosion	1	2	..
(C).—Undue pressure, defective blow off, or manlid unfastened too soon	14	15	31
	27	29	52
ECONOMISERS.			
(C).—Undue pressure	1	..	..
VALVES OR PIPES.			
(C).—Over pressure	1	2	..
Not ascertained	9	2	18
	10	4	18
KIND NOT ASCERTAINED	2	..	4

Total number of boilers exploded 630
Total number of persons killed 706
Total number of persons injured 1219

TABLE V.

RETURN OF PERSONS KILLED OR INJURED BY RAILWAY ACCIDENTS, FROM 1870 TO 1876 INCLUSIVE.

	1870.		1871.		1872.		1873.		1874.		1875.		1876.	
	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.
Passengers, from causes beyond their own control	66	1084	12	845	24	1247	40	1522	86	1613	17	1212	38	1279
Total Passengers	90	1094	57	896	127	1462	160	1750	211	1981	134	1806	139	1883
Total Servants, etc.	196	145	347	365	1018	1576	1212	1360	1213	3060	1156	3949	1106	2841
TOTAL.....	286	1239	404	1261	1145	3038	1372	3110	1424	5041	1290	5755	1245	4724

TABLE VI.

NUMBER OF PERSONS KILLED OR INJURED BY BOILER EXPLOSIONS AND BY RAILWAY ACCIDENTS, FROM 1870 TO 1876 INCLUSIVE.

YEAR.	Boiler Explosions.		All on Railways.		Passengers, from causes beyond their own control.	
	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.
1870	85	138	286	1,239	66	1,084
1871	66	113	404	1,261	12	845
1872	50	137	1,145	3,038	24	1,247
1873	66	94	1,372	3,110	40	1,522
1874	77	198	1,424	5,041	86	1,613
1875	81	142	1,290	5,755	17	1,212
1876	93	110	1,245	4,724	38	1,279
TOTAL.....	518	932	7,166	24,168	283	8,802

	Killed.	Injured.
Average boiler explosions	74	133
" all on railways	1,023	3,452
" passengers, from causes beyond their own control ...	40	1,257

TABLE VII.

FOREIGN INSPECTION SOCIETIES.—FRENCH, &c.

FRENCH EXPLOSIONS, TEN YEARS, FROM 1868–1877.—FROM "ANNALES DES MINES."

Only the numbers of exploded boilers are given for the first five years, but the killed and injured are mentioned in the last five years.

There were 243 explosions in the ten years; of these 145 were in the five years, 1873–1877, killing 185 persons and injuring 225.

THE EXPLODED BOILERS WERE USED FOR THE FOLLOWING PURPOSES.

	1868-1872.	1873-1877.	Killed.	Injured.	Total Boilers.
Ironworks	8	21	58	76	29
Mines and quarries	5	3	1	3	8
Steamboats	6	15	23	11	21
Mills for cotton, wool, or flax spinning, weaving, or winding...	19	13	14	3	32
Chemicals	..	3	3	3	3
Sugar and distilling	8	21	21	34	29
Corn factor	..	7	4	7	7
Paper making	5	8	13	17	13
Railways	3	3	..	6	6
Various works not divided	33	..	..	..	33
Corn mills	6	8	8	22	14
Oil and size mills	1	2	5	3	3
Candle and lamp making	1	2	1	3	3
Leather making	1	3	1	2	4
Sawing and turning	1	7	10	8	8
Dyeing and bleaching	1	16	10	10	17
Motive power	..	1	1	2	1
Printing	..	2	..	4	2
Brick making	..	1	..	..	1
Carried forward ...	98	136	173	214	234

	1868-1872.	1873-1877.	Killed.	Injured.	Tota Boilers.
Brought forward ...	98	136	173	214	234
Farms	..	2	3	3	2
Brewing	..	3	2	3	3
Butcher	..	1	1	..	1
Pile driving...	..	1	..	1	1
Brassworks	..	2	6	4	2
	98	145	185	225	243

TABLE VIII.

THE BOILERS WERE OF THE FOLLOWING KINDS.

	1868-1872.	1873-1877.	Killed.	Injured.	Total Boilers.
WITHOUT FLUES INSIDE.					
Horizontal, with or without heaters ...	24	51	41	64	75
Tubular do. ...	10	7	10	7	17
Vertical do. ...	..	7	50	59	7
Spherical	..	1	..	1	1
Belleville	..	2	1	4	2
Parallel tubes	..	1	1	1	1
WITH FLUES INSIDE.					
Horizontal	28	11	11	12	39
Tubular	3	..	..	..	3
Vertical	9	7	6	4	16
Boat...	..	15	23	11	15
Field	..	1	1	..	1
Herman and Chapelle	..	1	..	..	1
Stills and kiers	23	24	30	31	47
Locomotives	..	8	3	14	8
Portable	..	7	8	17	7
Damaged fittings	1	..	..	..	1
Unrecorded	..	2	..	..	2
	98	145	185	225	243

TABLE IX.

THE CAUSES OF EXPLOSION WERE.

	1868-1872.	1873-1877.	Killed.	Injured.	Total Boilers.
FROM FAULTS OF CONSTRUCTION.					
Bad design	20	25	24	30	45
Bad materials	..	7	3	8	7
FAULTS IN WORKING.					
Wear	5	15	37	49	20
External corrosion	..	13	28	31	13
Internal corrosion	..	3	5	8	3
FAULTS OF FITTINGS OR ATTENDANTS.					
Want of water	..	33	30	21	33
Undue pressure	..	3	3	13	3
Negligence of stoker	57	14	20	14	71
Faults unknown	8	11	18	28	19
Extraneous	8	..	..	..	8
Stills...	..	21	17	23	21
	98	145	185	225	243

TABLE VI.

NUMBER OF PERSONS KILLED OR INJURED BY BOILER EXPLOSIONS AND BY RAILWAY ACCIDENTS, FROM 1870 TO 1876 INCLUSIVE.

YEAR.	Boiler Explosions.		All on Railways.		Passengers, from causes beyond their own control.	
	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.
1870	85	138	286	1,239	66	1,084
1871	66	113	404	1,261	12	845
1872	50	137	1,145	3,038	24	1,247
1873	66	94	1,372	3,110	40	1,522
1874	77	198	1,424	5,041	86	1,613
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TOTAL.....	518	932	7,166	24,168	283	8,802

	Killed.	Injured.
Average boiler explosions	74	133
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TABLE VII.

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THE EXPLODED BOILERS WERE USED FOR THE FOLLOWING PURPOSES.

	1868–1872.	1873–1877.	Killed.	Injured.	Total Boilers.
Ironworks	8	21	58	76	29
Mines and quarries	5	3	1	3	8
Steamboats	6	15	23	11	21
Mills for cotton, wool, or flax spinning, weaving, or winding...	19	13	14	3	32
Chemicals	..	3	3	3	3
Sugar and distilling	8	21	21	34	29
Corn factor	..	7	4	7	7
Paper making	5	8	13	17	13
Railways	3	3	..	6	6
Various works not divided	33	..	..	..	33
Corn mills	6	8	8	22	14
Oil and size mills	1	2	5	3	3
Candle and lamp making	1	2	1	3	3
Leather making	1	3	1	2	4
Sawing and turning	1	7	10	8	8
Dyeing and bleaching	1	16	10	10	17
Motive power	..	1	1	2	1
Printing	..	2	..	4	2
Brick making	..	1	..	..	1
Carried forward ...	98	136			

	1868-1872.	1873-1877.	Killed.	Injured.	Tota Boilers.
Brought forward ...	98	136	173	214	234
Farms	..	2	3	3	2
Brewing	..	3	2	3	3
Butcher	..	1	1	..	1
Pile driving...	..	1	..	1	1
Brassworks	..	2	6	4	2
	98	145	185	225	243

TABLE VIII.

THE BOILERS WERE OF THE FOLLOWING KINDS.

	1868-1872.	1873-1877.	Killed.	Injured.	Total Boilers.
WITHOUT FLUES INSIDE.					
Horizontal, with or without heaters ...	24	51	41	64	75
Tubular do. ...	10	7	10	7	17
Vertical do. ...	..	7	50	59	7
Spherical	..	1	..	1	1
Belleville	..	2	1	4	2
Parallel tubes	..	1	1	1	1
WITH FLUES INSIDE.					
Horizontal	28	11	11	12	39
Tubular	3	..	..	..	3
Vertical	9	7	6	4	16
Boat...	..	15	23	11	15
Field	..	1	1	..	1
Herman and Chapelle	..	1	..	..	1
Stills and kiers	23	24	30	31	47
Locomotives	..	8	3	14	8
Portable	..	7	8	17	7
Damaged fittings	1	..	..	..	1
Unrecorded	..	2	..	..	2
	98	145	185	225	243

TABLE IX.

THE CAUSES OF EXPLOSION WERE.

	1868-1872.	1873-1877.	Killed.	Injured.	Total Boilers.
FROM FAULTS OF CONSTRUCTION.					
Bad design	20	[illegible]	24	30	45
Bad materials	[illegible]	[illegible]	3	8	7
FAULTS IN WORKING.					
Wear	[illegible]	[illegible]	[illegible]	49	20
External corrosion ...	[illegible]	[illegible]	[illegible]	[illegible]	13
Internal corrosion ...	[illegible]	[illegible]	[illegible]	[illegible]	3
FAULTS OF FITT[illegible]					
Want of water ...	[illegible]	[illegible]	[illegible]	21	33
Undue pressure	[illegible]	[illegible]	[illegible]	13	3
Negligence of [illegible]	[illegible]	[illegible]	[illegible]	14	71
Faults unk[illegible]	[illegible]	[illegible]	[illegible]	28	19
Extrane[illegible]	[illegible]	..	[illegible]	..	8
Stills	..	21	[illegible]	[illegible]	21
	98	[illegible]	[illegible]	[illegible]	[illegible]

TABLE X.

BOILERS IN GERMAN EMPIRE IN YEAR 1877.

I.—Causes of Explosions of Different Kinds.

(A) Cornish.		
1.—Weak tube	3	
2.—Weak material	1	
3.—Corrosion	2	
4.—Short water	2	
5.—Undue pressure	1	
6.—Defective fittings	1	
	—	10
(B) Lancashire.		
1.—Weak tubes	1	
2.—Short water	2	
	—	3
(C) Revolving and Heaters.		
1.—Weak manhole...	1	
2.—Corrosion	1	
3.—Careless attendant	1	
	—	3
(C 1) Revolving Vertical.		
1.—Corrosion	1	
2.—Short water	1	
	—	2
(D) Marine.		
1.—Undue pressure	1	
	—	1
(E) Oval—Two Tubes.		
1.—Undue pressure	1	
	—	1
Total number of explosions		20

II.—Causes Only.

(A) Bad Construction or Material.		
1.—Weak tubes	4	
2.—Weak manhole...	1	
3.—Weak material...	1	
	—	6
(B) Faults to be Corrected by Examination.		
1.—Corrosion	1	
2.—Crack in shell	3	
	—	4
(C) Careless Attendance.		
1.—Short water	4	
2.—Undue pressure	3	
3.—Blow-off defective	1	
4.—Scale or mud	1	
5.—Uncertain	1	
	—	10
Total		20

III.—Uses.

	No. of Boilers Exploded.	No. of Persons Killed.	No. of Persons Injured.
Wine, spirits, and beer	5	8	12
Colliery	4	3	4
Iron, &c.	3	4	10
Weaving and spinning	3	4	5
Chemical, sugar, and salt	3	2	6
Saw mill	1	...	...
Marine	1	...	...
Total	20	21	37

TABLE XI.

Boilers under Inspection of Foreign Companies, classified according to uses.

	No. of Boilers.
Asphalte factory...	23
Commercial traffic and lifts ...	401
Laundry and washing establishments	119
Colliery	1,442
Feather cleaning	5
Distillery...	489
Brewery	387
Printing	11
Cement factory	62
Chemical factory	466
Chocolate and coffee	24
Chicory	31
Thrashing machines	3
Ink and colour factory	171
Manure	71
Iron work	873
Dyeing and bleaching	182
Fire engines	2
Fire engine manufactory ...	1
Cloth factory	190
Flax dressing	1
Gas	155
Tanning and shoes	202
Bookbinding	139
Gum factory	46
Casting	9
Wood and ivory carving, &c. ...	71
Pencil factory	1
Boiler works and various boilers	509
Wool and stocking factory ...	389
Carried forward ...	6,475

	No. of Boilers.
Brought forward ...	6,475
Copper, zinc, brass, &c.	61
Lime and mortar	30
Machine making	761
Mineral works, water, &c. ...	66
Mills, various	416
Mints	2
Farinaceous foods, &c.	386
Paper and pasteboard	452
Pump making	2
Locomotive	109
Salt	8
Mustard	2
Umbrella and brush	4
Lock manufacture	4
Spinning, cotton, and linen ...	488
Starch	71
Lithography and stone engraving	21
Tobacco, cigars, &c.	41
Tapestry and embroidery ...	356
Clay, bricks, and tiles	249
Turf	16
Ultramarine	24
Agricultural	191
Wheelwright, &c.	48
Glass	54
Wearing	390
Sugar	1,419
Button	4
Cord, rope, twine and thread (hemp and wire)	92
Carried forward ...	12,242

	No. of Boilers.
Brought forward ...	12,242
Steel and cutlery	53
Dynamite, firearms, &c.... ...	9
Sulphur	4
Joiner, &c.	6
Polishing	1
Slate, stone, &c....	67
House, theatre, &c., ventilation	141
Steam plough	6
Candle and soap	56
Carried forward ...	12,585

	No. of Boilers.
Brought forward ...	12,585
Malt	29
Oils, various, and lamps ..	129
Water works	136
Wine making	24
Builders' and woodworking machinery	287
Musical instruments	17
Clocks and watches	17
Steam engines and fittings for do.	266
Uses not reported	7,103
Total	20,593

TABLE XII.

CLASSIFIED ACCORDING TO KINDS.

One smoke tube, Cornish	1,703
Do. do. 1 under boiler	120
Do. do. outside fire	84
Do. do. do. 1 heater	18
Two smoke tubes, Lancashire or Fairbairn	2,028
Do. do. outside fire	195
Do. do. do. 1 heater..	37
Do. do. do. 2 or more	85
Winkel	15
Galloway	151
Lancashire and tube boiler combined	63
Unknown	54
Multitubular, horizontal tubes	347
Do. Piedbœuf	15
Do. with firebox	37
Do. upright, vertical tubes	83
Do. do. horizontal tubes	1
Do. fish-mouth	1
Various	33
Portable agricultural	570
Locomotive	82
Marine	122
Field	168
Davy-Paxman	1
Meyn	15
La Chapelle	42
Howard	5
Belleville	35
Root	41
Steinmuller	12
Pauksch and Freund	181
Cylinder, plain	523
Carried forward	6,867

Brought forward	6,867
Cylinder, 1 under boiler	600
Do. 2 or more	2,011
Do. vertical	305
Do. do. fired inside	15
Do. 1 smoke flue, fired under	662
Do. 2 or more flues	366
Do. 1 smoke flue and under boiler	20
Do. 2 do. do.	145
"Bouilleur" boilers, 1 bouilleur	287
Do. 2 do.	141
Do. 1 or 2 do.	52
Artige	10
Henschel system	66
Farcot do.	25
Multitubular, fired under	121
Do. (Weinlig)	3
Revolving, plain	483
Do. 1 bouilleur	492
Do. 2 or more do.	1,692
Dupuis	83
"Tenbrink" boiler	1
Chevalier	1
Fouch	3
Schwanz boiler	32
Return tube boiler	267
Andere system	17
Wolf	1
Thomas and Lawrence	20
	14,788
Not reported	5,805
Total number	20,593

TABLE XIII.

Classified according to Pressure.

2 atmospheres and under	897
3 do. do.	1,012
4 do. do.	5,058
5 do. do.	5,961
6 do. do.	2,808
7 do. do.	283
8 do. do.	99
9 do. do.	3
10 do. do.	109
12 do. do.	14
14 do. do.	1
16 do. do.	1
20 do. do.	1
Not mentioned in Reports	4,346
Total No. of Boilers	20,593

TABLE XIV.

EXPLOSIONS, 1871-78.

(A).—Taken from German Reports.—Showing Number in Company and of Explosions.

	1871.		1872.		1873.		1874.		1875.		1876.		1877.		1878.	
	No. in Co.	E.	No. in Co.	E.	No. in Co.	E.	No. in Co.	E.	No. in Co.	E.	No. in Co.	E.	No. in Co.	E.	No. in Co.	E.
1. Hanover ...	...	...	...	...	153	...	283	...	448	...	525	1	...	1	...	...
2. Barmen ...	...	...	...	...	...	...	...	...	358	...	368	...	374	...	414	...
3. Halle ...	...	...	...	...	206	...	302	...	343	3	384	...	423	...	...	...
4. Breslau ...	102	...	150	...	305	...	398	...	560	...	...	...	672	1	612	...
5. Offenbach ...	...	...	...	...	...	...	...	...	390	...	462	...	540	...	546	1
7. Hamburg ...	231	...	304	...	408	...	488	...	528	1	641	...	662	...	662	...
8. Mannheim ...	470	...	512	...	604	...	650	...	...	...	810	...	1,072	...	...	...
9. Munchen ...	562	...	724	1	830	...	930	...	956	2	1,176	5	1,301	2	1,422	1
10. M. Gladbach ...	...	...	...	...	...	...	218	1	363	...	...	...	...	...	380	...
11. Magdeburg ...	233	...	373	...	725	4	1,048	...	1,200	1	1,265	2	1,300	...	1,388	...
12. Mulhouse ...	761	3	822	...	957	...	1,079	...	1,332	1	1,367	...	1,470	4	...	...
13. Aachen ...	...	...	...	...	...	...	...	...	...	...	440	...	337	...	356	...
14. Bernburg ...	...	...	...	...	...	...	...	...	597	...	618	...	640	..	660	...
15. Frankfort ...	...	...	...	...	...	...	...	...	...	1	324	...	422	1	476	...
16. Kaiserslautern..	...	...	...	...	...	...	504	1	574	...	...	...	...	...	919	...
18. Siegen ...	...	...	...	...	...	...	...	...	374	...	...	...	413	...	423	...
19. Vienna ...	...	...	...	...	1,554	...	1,944	1	2,699	2	2,952	...	...	...	...	1
20. Lucerne ...	...	...	...	...	...	1	...	1	874	...	1,046	3	1,182	1	1,275	...
21. Saarbrück ...	...	...	...	...	...	...	411	...	462	...	510	...	546	...	542	...
28. Neuwied ...	...	...	...	...	...	...	...	...	...	1	355	...	...	...	...	...
	2,359	3	2,885	1	5,742	5	8,255	4	12,058	12	13,243	11	11,354	10	10,075	3
(B).—Taken from French Reports.																
6. Brussels ...	...	...	...	...	496	12	607	...	1,298	...	1,554	...	1,740	...	...	...
23. Paris	...	...	...	...	...	...	...	...	143	...	157	2	200	...	254	...
24. Lyons	...	...	...	...	...	...	...	...	...	...	200	...	212	...	271	...
25. Lille	...	...	...	...	...	...	...	...	...	...	...	1	985	...	...	...
26. Chemnitz ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	288	6
27. Rouen... ...	...	...	...	...	...	...	...	...	335	...	200	...	449	1	...	...
	...	...	...	...	496	12	607	...	1,776	...	2,111	3	3,586	1	813	6

TABLE XV.

CAUSES OF EXPLOSIONS.—TAKEN FROM FRENCH AND GERMAN REPORTS.

YEARS, 1871–78.

	German.		French.	
A.—LANCASHIRE—				
1.—Defective fittings	1		... ...	
2.—Short water	4		... ...	
	—	5		
B.—CORNISH—				
1.—Weak construction ...	3		... ...	
2.—Short water	2		... 1	
	—	5	—	1
C.—MARINE—				
1.—Weak construction ...	1		... ...	
2.—Corrosion	1		... ...	
3.—Scale and mud	1		... ...	
	—	3		
D.—PLAIN CYLINDER—				
1.—Weak construction ...	8		... ...	
2.—Defective fittings ...	5		... ...	
3.—Short water	5		... 1	
4.—Undue pressure	3		... 1	
5.—Corrosion	1		... 1	
6.—Uncertain	2		... 1	
	—	24	—	4
E.—TUBULAR—				
1.—Short water	1		... 1	
2.—Undue pressure	2		... ...	
	—	3	—	1
F.—BOUILLEUR—				
1.—Short water	1		... 1	
2.—Undue pressure	1		... ...	
3.—Corrosion	...		... 1	
	—	2	—	2
G.—REVOLVING—				
1.—Weak construction ...	1		... ...	
	—	1		
H.—VARIOUS	6		... 14	
	—	6	—	14
Total		49		22

Mr. D. P. MORISON stated, that in a third paper he intended to take up the subject of the setting and arrangement of boilers and their flues, and he hoped to get the assistance, as far as possible, of the members of the Institute. In a further paper he proposed to deal with the materials and construction of the boilers themselves. He might add, that Mr. Marten had been kind enough to lend a most valuable set of models for the proper elucidation of the paper; and one of their inspectors, Mr. Winship, was present and would be glad to explain them to any member who would like to see them.

The PRESIDENT asked, whether it would be better to have the discussion now or wait till the whole of the papers were forthcoming before having a general discussion on the whole? He supposed that before Mr. Morison had finished he would be able to tell the members which was the safest kind of boiler, and also to tell them under what conditions the greatest safety could arise from the working of that boiler.

Mr. MORISON said, that as they had the advantage of Mr. Marten's presence, there were one or two points in connection with boilers which his practical experience would enable him to explain, and which perhaps it would be an advantage to the members present to hear.

The PRESIDENT said, he was sure the meeting would be very glad to hear anything which Mr. Marten had to say upon the subject.

Mr. E. F. BOYD proposed a vote of thanks to Mr. Morison for the very interesting details which he had given the members. He (Mr. B.) must express the hope that every gentleman who was concerned in his own department of trade would render every assistance to Mr. Morison in trying to make as complete as possible the remaining papers which he proposed bringing before them.

The motion, seconded by Mr. NEWALL, was carried by acclamation.

Mr. MARTEN said, of course it would have been more convenient if he had been able to hear such questions as might occur to the members in the discussion, and so if possible to have answered them. He thought the object of the last paper was to ascertain whether the inspection of boilers was really necessary, or whether boilers may, if they are good, be left to themselves without inspection. His own conviction was extremely strong on the subject that, no matter how good a boiler might be, inspection should be added, for no boiler can be relied upon that has not been surveyed in all its details at least once a year, and he thought that the Institution would arrive at the same conclusion. All boilers, even of the very highest class, and made by the most careful firms, have still been liable to explosion. Evils had arisen

which had been thought never would arise, but which in practice do arise, and therefore his opinion was very strong—that somebody ought to see and if possible feel every part of a working boiler at least once a year. The reason why he acceded to the request to bring before them these models of exploded boilers was, that he thought there still remained many of the old mysterious ideas of explosions; for instance, that they arise from electricity, or from the decomposition of steam, or the spherical condition of water; and he thought, therefore, that more careful investigations by those gathering their experience from many explosions would be extremely useful. He had taken very great pains to obtain the record of every explosion which had taken place since 1800. He found no other method of investigation so good as making a model of all the parts and placing them, first in the position in which they were before the explosion, and then in the position in which they were found after the explosion; this done, the place where the boiler first gave way became almost invariably apparent, and the investigation was narrowed into what made that particular place give way, and it was very seldom indeed that any mistake could be made; but it was too often the case that a cursory view of an explosion produced the idea that there must have been some greater force in the boiler than the mere compression of steam; whereas, if a calculation was carefully made, it would be found that there was no working boiler but had force enough within it to blow it all to pieces if only a first rent is made. Perhaps he need say very little about any particular system of inspection; that will best be spoken of at a future meeting. If the members should come to the conclusion that inspection of some kind was desirable, his own view was that it was best done, not by Government, but by the owners themselves selecting the person who should do it; because then those who did it would have to do it well, or they would not be employed, and the responsibility to the owners would still remain. He thought that this was much more desirable than that the inspection should be entrusted to an irresponsible set of Government Inspectors of which it would take something like 200 to attend properly to the business.

There was a class of boilers generating steam at from 500 to 600 pounds to the inch; that was not very generally known; and he, thinking it would be interesting to the members present to hear some account of the system, had brought with him one of the tubes of a Perkins' boiler, and he asked to be allowed to use it as an illustration of what he considered to be the theoretically perfect way of using a boiler. Some of the gentlemen present were very likely familiar with Perkins' field ovens for the use of an army when in the field, a section of which is shown in Plate II., Fig. 1. They consisted

of a number of pipes about half an inch internal diameter, with a small quantity of water in the end within the fire. As the heat was taken from the steam in the top part of the pipes by the oven, the condensed steam fell to the bottom in the shape of water and was re-circulated as before without any loss of the original supply. In manufacturing these tubes one end is first welded up and enough water put in to fill one-tenth of the length; the other end is then put into a smith's fire and welded up solid. During this process about ten inches of the tube becomes red-hot. As soon as the blacksmith has finished welding it up he turns it over, and the water runs into the red-hot part. The first effect of this is that the red-hot part becomes rapidly chilled, but the hitherto cool part almost instantly becomes very hot, showing that the water is quickly converted into steam, and he believed the pressure in the tube thus manipulated was fifteen atmospheres. This illustrated the fallacy of the often repeated statement that if cold water is poured on to a red-hot boiler it must necessarily explode, for every day hundreds of these are turned over in this way without accident. He thought that the tube receiving the water so suddenly into the hot end might be compared to a boiler, the flue of which is red-hot by misadventure, and that the circumstance of the tube not exploding combated very much the theory that boilers must explode simply by throwing cold water into their red-hot flues. This Perkins' boiler was also mentioned as an illustration of what was ultimately hoped for in boiler engineering. He thought this oven tube was very useful as showing how steam might be generated over and over again from the same water without any loss, and thus all the difficulties attendant on the deposit caused by the introduction of so much fresh water into the boilers at present in use would be avoided. In Plate II., Fig. 2, a slight sketch was given of the Perkins' engine, which was driven by a number of tubes made in the same way as those for the oven, where the steam at a pressure of 400 or 500 lbs. to the inch was utilized, condensed, and returned into the lower end of the tube with scarcely any loss. He had seen one of Mr. Perkins' engines which had worked eight years, during which time the boiler had received but very little additional water. A great many difficulties could be got over if the ordinary working boilers could be made to assimilate to something like this conditon. He did not think it could be done at once, but it was a very good example to keep before them of what he thought was a perfect use of steam. With regard to inspection, he thought that no attempt should be made to persuade the public to adopt any particular kind of boiler, but that the inspectors should endeavour to cause those boilers, which the proprietors thought most

suitable for their particular purposes, to be so constructed and maintained as to be as safe and durable as possible, and he had always kept this before himself and the officials whom he directed.

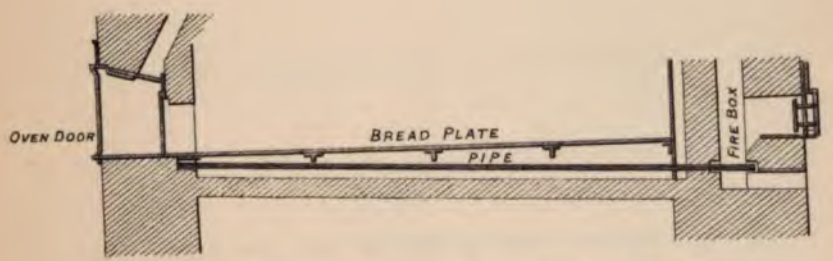
Mr. R. S. NEWALL said, Mr. Marten had referred to Perkins' engine but had not referred to a steamer on the Tyne which is fitted up with such a boiler and engine, which works at a pressure of 450 lbs. to the inch, and in which the water is so condensed and used over again as to require a very small additional supply to the quantity originally introduced. There was a very great saving of fuel by the process, as Mr. Perkins had stated that the consumption was less than a pound and a half per horse power per hour.

The next paper for reading was one by Mr. Edwin Gilpin, A.M., F.G.S., Inspector of Mines, entitled "Notes on Nova Scotia Pit Waters."

The PRESIDENT said, the gentleman who had presented this paper resided at a distance, and, as it seemed to be a subject which required study and did not well admit of being read in public, perhaps it would be well to have it printed and laid before the members and then discussed.

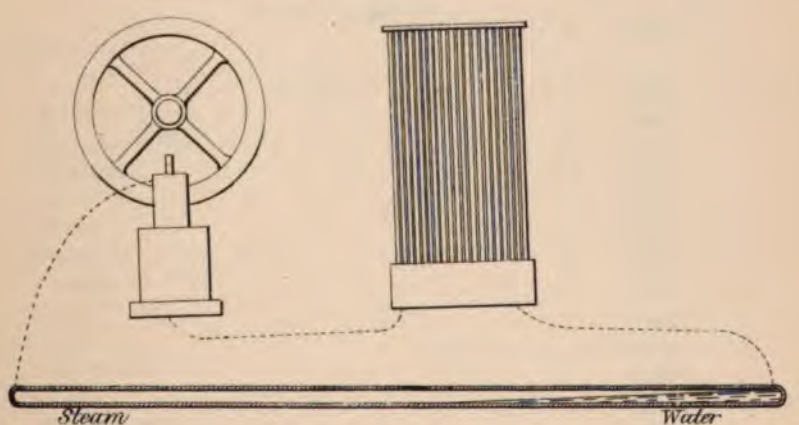
The paper was then taken as read, on the understanding that it be printed in the Transactions, and the meeting terminated.

To illustrate Mr. E. B. Marten's remarks on Perkins' Field Ovens.



Sketch showing position of heating Pipe as used in Perkins' Oven.

Outline of Perkins' Engine & Condenser which return all the water at high temperature to the Boiler.



Sketch of short sample tube exhibited.

And. Reid, Newcastle.

NOTES ON NOVA SCOTIA PIT WATERS.

By EDWIN GILPIN, A.M., F.G.S., Inspector of Mines.

The composition, sources, and effects of the hidden springs of the earth are as yet so little known, and the field for investigation is so wide and varied, that the time has not yet arrived for reliable deductions; but it may be expected that at some future day the composition of mineral springs and the waters cut by boreholes, &c., may be brought into the service of man, and furnish valuable information about the proximity of mineral deposits and strata.

So far as the writer is aware, but four analyses have as yet been made of Nova Scotia pit waters. Two of these are of waters from the Pictou coal district, and two from the Cape Breton district; they, however, represent fairly the characteristics of the waters of the two districts.

At the Blockhouse Colliery, Cape Breton, the pit water has a corrosive effect on the ironwork exposed to its action. The following analysis was made in the laboratory of the Canadian Geological Survey, 1872-73:—

Suspended Matter.	
Sulphate of iron	·1510
In Solution.	
Iron (aspersalt)	·2426
Iron (asprotosalt)	·1168
Manganese	·0078
Aluminium	·0420
Calcium	·1498
Magnesium	·0618
Potassium	·0134
Sodium	·1884
Silica	·0116
Sulphuric acid	1·4808
Chloric	·4100
Phosphoric acid	traces
Organic matter	·2844
Total constituents in 1,000 parts	3·0094

Water, yellowish-brown colour, acid reaction, and styptic taste.

The Blockhouse Seam immediately overlies the Gowrie Seam, worked by Messrs. Archibald. In Vol. XXVI., p. 56, of the Transactions, there is an interesting account of the difficulties that gentleman met with in overcoming the destructive effects of the water found in their pit. There is no analysis of the water from the Gowrie Mine, but, from its appearance and action, there is no doubt but that the analysis given above will also indicate its composition.

At several other collieries in the Cape Breton district similar corrosive powers appear in the pit waters, and have caused much annoyance to those engaged in conducting mining operations.

Direct-acting force pumps are very generally employed, and frequently require replacement of the iron working parts by compositions similar to that used at the Gowrie, such as brass, babbit metal, and lignum vitæ. No doubt the heat induced by the steam would tend to increase this corrosive tendency, but the portability of these pumps, and the general adoption of slope winnings, cause their retention. When, through ignorance or a false economy, these waters are introduced into the colliery boilers, an immediate and energetic corrosion takes place. The boilers used in Cape Breton, with a few exceptions, are cylindrical egg-ended, externally fired. The action of the water is shown by cutting the rivet heads—severe pitting, a planing away of some of the plates over a space of several square inches, and generally a deposit of hard scale on the lower back end plates.

A scum-collector, invented by Mr. W. M. Rumble, Mechanical Superintendent, Cape Breton Coal Co., has been found to materially prevent the destructive effect of these waters at the Emery Colliery. The description of it is from the Report of the Inspector of Mines for 1877:—"It may be described generally to consist of a two-inch pipe leading from near the back end of the boiler up to an 18-gallon receiver, placed above the boiler and nearly over the fire bridge; from the receiver pass two pipes, one to the open and the other directly downwards through the shell to low-water line, where it branches into two transversely-placed bell mouths, each having a diameter equal to the difference between high and low-water in the boiler. The circuit being made by the necessary valves, a current of water flows through the system in a contrary direction to the order of the above description. Then as the strongest ebullition occurs where the bell mouths are placed, the scum in the water is thrown to the surface and passes up into the receiver where it settles, and from which it is periodically blown out through the second pipe."

The pit water from the Gardener Colliery has developed all the above injurious qualities in a marked manner. The following analysis of this

water, made by the writer some time ago, shows a composition similar to that of the Blockhouse water :—

Iron sulphate	2·750
Potassium sulphate	·185
Calcium carbonate	·736
Magnesium carbonate	·025
Sodium chloride	·960
Alumina	trace
Silica	·225
Total in 1,000 parts	4·881

Water, clear with bluish shade; after standing, deposited reddish sediment; acid reaction, and highly styptic taste.

This water also exerted a corrosive action on the force pumps and the wrought-iron rising columns. The action on the latter was mitigated by a coating of oxide of iron deposited by the water. As this coating was nearly one-half inch thick in a 5-inch pipe, the partial protection thus afforded was attended with a lessened area through the pipe.

Passing to the Pictou coal-field there is a class of waters of a totally different character and of a comparatively innocuous nature. The following analysis of the pit water of the Vale Colliery, made by the writer a short while ago, is as follows :—

Iron and alumina	traces
Magnesium carbonate	"
Calcium carbonate	"
Sodium chloride	1·452
*Sodium carbonate	7·509
Magnesium sulphate	·100
Calcium sulphate...	·514
Potassium	traces
Silicious matter	·190
Organic matter	trace
Total in 1,000 parts	9·765

Water, clear and colourless; at first it gave no reaction, but after boiling became alkaline.

* The percentage of sodium carbonate appeared so large that the determination was repeated, and the former result confirmed; the percentage given is an average of both determinations.

This water has been used a little as a boiler feed, and has not shown any injurious effects.

The second analysis of Pictou pit water now given is one of the water from the Nova Scotia Colliery, situated at the western extremity of the

district, made by Dr. H. How, King's College, Windsor, N.S., giving the following results :—

Silica	·460
Calcium carbonate	10·590
Magnesium carbonate	3·570
Iron carbonate	traces
Sodium chloride	1·170
Potassium sulphate	1·580
Sodium sulphate	2·500
Sodium carbonate	3·350
Phosphoric acid	none
Organic matter	traces
	23·220

Water, bright and clear; no odour, slightly acid; after boiling gave alkaline reactions. Calculated in grains to the imperial gallon.

These waters have been used to some extent mixed with surface water, with no markedly injurious effects.

On comparing the Pictou and Cape Breton pit waters it will be at once seen that the latter contain very large quantities of iron sulphates, and the former large percentages of alkaline carbonates. These waters all differ from any of the Canadian pre-carboniferous waters, which are fully described by Dr. Sterry Hunt in Sir William Logan's "Geology of Canada," 1863. The Canadian waters, arising from comparatively undisturbed measures, present constituents derived from limestones, dolomites, argillaceous sediments, and feldspathic rocks, which admit of their division into six classes. The number of Nova Scotia pit waters analysed is too small to admit of any deductions which can be considered reliable. But there are a few points, which may to some extent account for these widely-divergent results. In considering the composition of these pit waters found in workings of moderate depths, it may be assumed that they are accumulated partly from surface water filtering downwards, and partly from water rising from lower measures by hydrostatic pressure through the strata, or by means of faults.

The strata containing the Cape Breton coals are largely composed of sandstones, many of which hold numerous disseminated crystals of iron sulphurets, while the shales which predominate in Pictou County are comparatively free from this ingredient. This and the larger percentage of iron pyrites and organic compounds of sulphur in the Cape Breton coals may account for the large amounts of iron sulphates the former contain. The preponderance of sodium chloride in the Pictou pit water may be explained by the fact that on the southern edge of the district,

whence the waters analysed were taken, the Lower Carboniferous limestones and gypsums come against the coal-measures with very little intervening millstone grit, and the heavy faults bounding the district would allow the admission of their waters to the workings. In Cape Breton, on the other hand, the coal-measures are comparatively undisturbed, and a great thickness of millstone grit must intervene between them and the marine (Lower Carboniferous) limestones. In both districts limestone is almost entirely wanting in the coal-measures.

The following analysis of a Cape Breton Lower Carboniferous water, from the Little Narrows of the Bras d'Or Lake, made by the analyst to the Geological Survey, 1873, is given for comparison :—

Sodium chloride...	50·6881
Potassium chloride	·1942
Magnesium chloride	·1592
Calcium sulphate	5·6810
Alumina...	traces
Silica	"
Ferric oxide suspended, originally present, probably as ferrous carbonate	·0054
Total in 1,000 parts	56·7279

This fairly represents the composition of the Lower Carboniferous waters, although in cases where they rise from highly gypseous portions of these measures, the calcium sulphate sometimes predominates.

This derivation of the sodium chloride from the marine limestones in the case of the Pictou waters may be supported by the fact that at the Vale Colliery, where the Lower Carboniferous measures are a comparatively short distance away, the cleats of the coal are frequently coated with films of selenite up to one-quarter of an inch in thickness ; and it will also be observed that the water from this mine contains a considerable amount of calcium sulphate. The unusually large percentage of sodium carbonate present in the waters from the Vale Colliery does not at first seem easily accounted for, unless it owes its origin to the argillaceous shales which were formed from the granites and silurian slates of the hills lying to the south of the district.

The comparatively small amounts of magnesium salts present in all the Nova Scotia pit waters may perhaps be owing to the fact that this mineral is not abundant in the province—an average of twenty analyses of Lower Carboniferous limestones giving but ·75 per cent. of magnesium carbonate.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, NOVEMBER 1ST, 1879, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

G. C. GREENWELL, ESQ., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting and the minutes of the Council Meetings.

The following gentlemen were then elected :—

HONORARY MEMBER—

Mr. G. A. LEBOUR, Professor of Geology, College of Physical Science, Newcastle-upon-Tyne.

STUDENT—

Mr. THOMAS B. MACKINLAY, West Pelton Colliery, Chester-le-Street.

The following gentleman was nominated for election at the next meeting :—

ORDINARY MEMBER—

Mr. JOSEPH POTTS, Jun., Architect and Surveyor, North Cliff, Roker, Sunderland.

Mr. C. Z. BUNNING then read the following paper by Mr. J. K. GUTHRIE and himself :—"Description of an Instrument for Ascertaining the Inclination, from the Perpendicular, of Boreholes, and the Direction of such Inclination."

DESCRIPTION OF AN INSTRUMENT FOR ASCERTAINING THE INCLINATION, FROM THE PERPENDICULAR, OF BOREHOLES AND THE DIRECTION OF SUCH INCLINATION.

By CH. ZIETHEN BUNNING and J. KENNETH GUTHRIE.

The instrument under notice is the invention of G. Nolten, Dortmund, Germany, who, although not connected with the mining profession, happened to overhear a discussion between some mining engineers as to the want of some such instrument, and was thus directed to the study of the question.

As in the case of many other discoveries, which are often the result of some apparently trivial circumstance, the sight of a ring or surface marginal mark left by some water, which had been standing for some time in a glass bottle, led Mr. Nolten to his first idea of the instrument.

The writers were directed to the study of this instrument by an article in a German scientific journal.

It is well known that boreholes, especially those bored with turning tools, are never perfectly perpendicular, but deviate more or less from the vertical; yet, until now, no method or instrument has been devised either to find this degree of inclination or its bearing.

The knowledge and application of such information must always be of the greatest importance if inference is wished to be drawn as to the exact vertical depth of such boreholes.

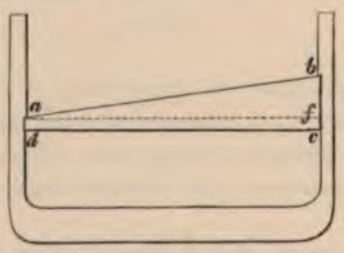
As many calculations depend upon depths from the surface, such as, for instance, the temperature of the earth's crust, depth of seams, thickness and dip of strata, etc.; and as these data are generally taken from boreholes, it must be obvious that the correctness of such calculations must depend greatly upon these depths being accurately known.

The depth of boreholes is generally taken upon the supposition that they are perpendicular, and that their measured depth is the vertical distance below the surface of the earth; but it has already been stated, that no borehole is in an exact perpendicular position, and in many cases significant deviations have been known to exist which would give an erroneous result by denoting a greater depth than is actually the case.

THE PRINCIPLE OF THE INSTRUMENT.

The working of this instrument depends upon two circumstances, viz.:—The fact of liquids always seeking their natural level; and, secondly, in recording the angle made by a liquid with any given base by the action of hydrofluoric acid in etching upon glass.

The annexed figure is a section of the instrument used to obtain the angle of deviation. It consists of a ground flat-bottomed colourless glass vessel, the sides of which are exactly at right angles to the bottom.



Into this vessel is poured one part of hydrofluoric acid to four parts of water, filling it half full.

If the instrument is then placed in an inclined position, so that, for instance, the water level takes the line of *a b*, and if kept still for half an hour, the level of the liquid will be marked in the shape of a ring upon the glass, which is formed in such a manner that exactly at the level of the liquid *a b* the inner part of the glass towards the bottom will be etched to the extent of one-tenth of its thickness.

Then some of the liquid is taken out, so that its level in a horizontal position will mark itself below the lowest line of the first mark.

The glass is then placed upon a perfectly horizontal surface, and being kept in this position for half an hour the liquid will make the mark *d c*.

By pouring out the liquid and cleaning the glass the two marks will be seen clearly and distinctly while the glass will remain perfectly transparent.

In the above figure from the height *b c* take the part *f c*, which is equal to *a d*, then the angle at *f* will be clearly a right angle, and the triangle *a f b* a right-angled triangle, of which the sides *a f* and *f b* are known, and therefore the angle *b a f* is also known, which is the angle of deviation from the perpendicular.

In practice the glass is placed in a water-tight instrument, of which Fig. 1, Plate III., is a section.

It has the form of a round-ended cylinder, with a rod passing through the top, having screwed ends, of which the top fits into the bore rods or rope used in lowering it.

The protruding flanges *k* and *b* are gutta percha rings, which prevent the instrument from falling heavily when being lowered.

With the exception of these parts the instrument is made of brass, on account of the magnetic needle which is enclosed.

The glass containing the etching liquid is closed with a lid and placed in the interior of the cylinder upon a plate which is set exactly at right angles to the sides of the cylinder.

During the lowering of the instrument the acid is in constant motion, and therefore the inner surface of the glass is etched equally all over.

The instrument is kept quietly hanging at any depth, where an observation is to be taken, for half an hour. It is then drawn up and the mark etched upon the glass is found unweakened, notwithstanding the lowering and bringing up, which, as before said, on account of the oscillations of the liquid, etches the glass regularly.

After cleaning the glass, the process before described is gone through—that is, a less quantity of liquid is poured in, so that the glass being held in a horizontal position, the level of the liquid will be a little below the lowest mark of the etched ring.

It is now again placed in the instrument, which is allowed to hang freely above the surface of the ground for half an hour, when of course it will be in a perpendicular position, and the acid will give the horizontal mark required.

This mark can also be obtained by allowing the glass to stand upon a perfectly horizontal surface.

Having thus obtained these lines, the angle of deviation from the perpendicular at a measured depth of the borehole is arrived at.

This result being obtained, there remains now to be found the direction of this deviation in a horizontal plane, that is, its magnetic bearing. This is found as follows :—The glass containing the etching liquid is fitted into a ring which is in rigid connection with a compass, and is similarly divided into degrees. If this connection, of which the glass with the ring and the compass are parts, is inclined in any direction whereby the line of inclination is found by means of the liquid in the glass, the direction in a horizontal position of this line is read off by the divisions on the ring in which the glass is set, if at the same time the compass is read, the difference of these readings will be the magnetic bearing of the line of inclination.

In carrying out this method in practice, it is necessary that the reading of the magnetic needle in the borehole should be recorded when the instrument is brought to the surface. This is accomplished by fastening the needle in the borehole, by means of a watch (forming part of the instrument), after sufficient time for settling has been allowed.

DESCRIPTION OF THE INSTRUMENT.

The cylindrical casing of the instrument is shown in section, Plate III., Fig. 1. The opening *a a* of the cylinder A, Fig. 1, is shown in Fig. 3 in section and in Fig. 4 in perspective. Into the space *d p* is fixed, by means of a rod, the instrument shown in Figs. 2 and 5, which consists of three plates, *a*, *e*, and *o*, Fig. 2, shown by dotted lines in Fig. 1.

These plates or divisions are placed at right angles to the longitudinal axis of the instrument, and are connected together by three vertical strips of brass, shown in Fig. 5.

Fig. 4 shows the inner projecting flange of the cylindrical casing, also seen in *a d*, Fig 1. This flange is divided into six equal parts, three of which are alternately cut out. Fig. 5 shows how the three plates are similarly cut out, so that they can slide through the projecting flange. After sliding the inner instrument through the flange in Fig. 4, it is turned one-sixth of its circumference towards the right, the catch *z* preventing it from going further; then the three outer projections of the upper plate in Fig. 5 will stand under the three inner projecting parts in Fig. 4.

The cover *o a*, Fig. 1, is now placed over the rod, which, by means of the nut *m*, can be tightly screwed down. The rounded end pieces in Fig. 1, held by nuts, are only used to round the instrument. The glass, containing the etching liquid, is placed in a brass ring, *k m o*, Figs. 9 and 10, which is fastened into the lowest plate, Fig. 2.

This glass is closed by a flat lid, the lower surface of which is lined with gutta-percha, and which is kept in its place by the cone *g h* and a screw above.

The compass is placed upon the middle plate, the pin upon which the needle swings being made high. Over the compass is placed the watch with its stop arrangement, which is shown in natural size, Fig. 1, Plate IV., and in Fig. 3 the lever arrangement is seen in twice its natural size. The watch is fastened on its upper side to the plate *c*, and on the lower side is soldered the pin *d* which keeps the watch in position by fitting into the hole in the guide *d*, shown in Fig. 6, Plate III.

The winding axle which is lengthened outwardly, and to which is connected a small metal plate *m*, Fig. 1, Plate IV., pushes the lever arrange-

ment by means of a pin towards the right; this pin is seen at *d* in the small anchor *d r f*, Fig. 3, Plate IV. This anchor is sketched as seen from above, and the rods under it are drawn in elevation. The former is placed in a horizontal position on the vertical rod *a b r*, upon which a movable rod turns on the axle *g*.

Upon the top of this rod the catch *f* is fixed which moves in the slotting *f* of the anchor, while the pin *r* of the latter fits into the hole *r* shown in the rod *a b r*. In the lower catch *p* the moving rod acts upon a brass spring *x*.

When this rod is moved towards the right, the spring is released and strikes the pin *h* in Fig. 1, which, on being pressed down, fixes the magnetic needle. In Fig. 2 the movable rod is shown in two positions before and after being stopped. The point *d* is kept out of reach of the plate *m* by the movable rod and retained in that position so that the watch is free to work. The anchor and movable rod are held fast in the position shown by the dotted lines. The stopping of the watch at any required time is effected by the placing of the plate *m*, in Fig. 1.

This plate, as shown in dotted lines in the figure, is placed at the number 4 if the watch is required to fix the needle after an interval of four-fourths of an hour, and is placed at the numbers 3 or 5, if it is desired to fix it at three-fourths or five-fourths of an hour respectively.

Should it take, for example, half an hour to lower the instrument to the measured depth where it is to remain, the stopping of the magnetic needle occurs when it is in perfect rest if the plate *m* is set on the number 3.

That the stopping of the needle is occasioned through the plate *m*, and not, perhaps, by the shaking loose of the spring in lowering, and also that it takes place at the required time, is proved by a small mark, made by a pencil fixed in the point of the anchor, upon a piece of paper fixed upon *m*.

The compass case, Fig. 1, is covered by a glass lid, kept in its place by a pin placed above. The upper rim of this lid is divided into a hundred parts, visible from within and without, and stands concentric with the ring (Figs. 9 and 10, Plate III., *k m o*) in which the acid glass is placed, the under half of which, *m o*, is also divided into a hundred parts, so that in both vessels the zero point and all other divisions stand vertically under each other.

The upper half of this ring is turned down to half its thickness seen in Fig. 10. Over this part a brass ring is fitted, which can be turned round and is divided into 360 degrees.

Suppose, for example, the north point of the needle in Fig. 2 is to the right. Also suppose the glass fixed into the ring, Fig. 10, has the etched marks shown in Fig. 7. The dip of the instrument will be towards the south, the dip being where the water level *a b* is lowest, therefore towards *a* which stands exactly opposite the north point if the marks are as shown.

In Fig. 8, with the lower curve as representing the lowest point which is exactly in the middle of the back side of the glass *x*, the dip will in this case be towards the west. If the upper curve in Fig. 8 represents the lowest point of the etching liquid at *y*, so will the dip be south-west.

To find easily and at the same time accurately the direction of the dip of the instrument, the position of the north point is compared with the before-described glass lid of the compass, which is divided into a hundred parts, and the number on the compass holder which happens to be opposite the north point of the needle when stopped.

Take, for example, this number to be 50. Then the movable ring *k m* is turned round until the zero point is over 50 on the bottom ring *m o*, which is concentric with, and similarly marked to, the divisions on the compass case above mentioned. Upon the movable ring, the zero point of which will be vertically under the north point of the needle, the bearing is read of the lowest point of the etched ring in the glass, which, in the example given in Fig. 7, is 180 degrees, and in Fig. 8, 270 degrees and 225 degrees respectively.

Finally, the Figs. 4, 5, 7, Plate IV., represent the screw press, which is placed over the lid of the instrument *a o*, Fig. 1, Plate III. The key, Fig. 6, works in the space *q* of the part Fig. 7. On this press being placed over the lid, pressure is brought to bear on the cover *a o* by means of the two screws shown in Fig. 4, the pressure being followed up by the nut *m o*, turned by the key Fig. 6; the whole of which is shown in section Fig. 5. After sufficient pressure has been brought to bear, the nut *h* is loosened and the parts 4, 5, and 7 taken off.

This covering, together with the packing round the rod, has been proved water-tight at a depth of 3,280 feet. The manner by which the middle rod is made water-tight is shown in Fig. 1, where *a d* represents a sort of metal gland, round the top inner edge of which packing is placed.

TRIAL OF THE INSTRUMENT.

This instrument has undergone many trials which, as regards accuracy and reliability, were successful; amongst others—

Two wrought iron tubes were connected together, making a length of

8½ feet, this tube was made fast, and the instrument placed first in the top, then in the middle, and lastly in the bottom. The acid mark gave the following results:—

No. 1 position, a dip of 83° 59′.
No. 2 „ „ 81° 2′.
No. 3 „ „ 81° 2′.

It is to be here noted that in the first position the instrument did not follow the inclination of the tube. The reading of the glass can be made more accurate if a gypsum impression is taken of the inner part of the glass. The curves formed on this cast, near the highest and lowest parts, are enlarged by photography two or three times, and upon the photograph the height of these two points is read by the Cathetometer. According to the trials above given, it was evident that the instrument would give the angle of inclination of a borehole as accurately as it could afterwards be plotted by the protractor.

Regarding the accuracy of the bearing of the dip of a borehole, trials were made in the same wrought iron tube. The bearing of this tube in the ordinary manner was found to be 114 degrees 22 minutes; the instrument gave at the top, however, 107 degrees, in the middle 75 degrees, in the bottom 176 degrees, giving an average of 119 degrees.

It will be seen from the above numbers that the individual readings differed considerably, while the averages differed only four or five degrees from the true position. This inaccuracy was evidently caused by the iron tube, the longitudinal seam of which made the iron double at one side; also where the two tubes were joined together there was an extra quantity of iron, thus making its attraction unequal.

The separate measurements therefore would never be correct, and the average of a number of measurements would be the only accurate way of finding the true result. In boreholes the results will not be much affected if the instrument is placed in the middle of the tube lining, and if the tubes are not possessed of longitudinal seams and joints. Also as two tubes, when joined together, will perhaps not be exactly in one plane, this instrument will not be able to take measurements in such positions.

There is yet another source of error, where different sized tubes are used, one within the other, in lining boreholes, these being nearer together in some places than in others. This error may however be corrected by taking a series of measurements, which may be individually wrong, the average of which however might be correct.

A gutta-percha flange is used to keep the instrument in the middle of the tube.

In consequence of the magnetism of the earth, the whole iron tube in a borehole becomes a magnet, of which the top is the South Pole and the bottom the North Pole; between these two ends, in the middle, there will be a neutral position. Nothing has been done to satisfactorily show the action of such a magnet on the magnetic needle, but very probably it would have the same effect as if an electric current was passed through a vertical wire spiral, in the middle of which a needle is poised. In the latter case the magnetic needle is placed so that it can move freely both horizontally and vertically; and if an electric stream is passed through, going in the direction of the hands of a watch, it will have the effect of sinking the north end of the needle, but will not hinder the horizontal movement. The same will also hold good in a perfectly homogeneous iron tube, when the declination of the needle will not be affected so long as the inclination of the needle is not in a vertical position, in which case of course the horizontal movement of the needle will be destroyed. In this instrument the magnetic needle is poised upon a high vertical pin, and its north end is loaded, so that under ordinary circumstances there will be no inclination. The instrument is so constructed that if the needle has a greater inclination than 18 degrees, it will not be free to move in a horizontal direction; therefore the angle of a borehole from the vertical, together with the effect of polar magnetism, which power is unknown and variable, must not be greater than this angle if the instrument is to be used. The instrument can, however, be tested as follows:—Observations must be taken several times in one and the same position, and if they at all resemble each other, it is obvious that the 18 degrees inclination has not been exceeded. However, from the foregoing, it will readily be understood, that in an iron-lined borehole, results in any way accurate can only be arrived at by taking a number of observations which will individually correct each other, and bring the result near the truth. In a borehole not lined with tubes the above sources of error entirely disappear; but in spite of this, care must be taken in observing the magnetic needle. Several observations should be made with the needle, to see that in the act of stopping, it has not got moved, and if these results anywhere resemble each other, it may be taken that the needle has not been moved.

In boreholes not much out of the vertical the instrument will be difficult to read, on account of the two acid-eaten marks (the angular and horizontal) running nearly parallel with each other, and therefore the point of the greatest and smallest deviation will be difficult to find exactly.

It will thus be seen that the finding of the inclination of a borehole will be subject to a small error, and the bearing to a larger one.

Although it cannot be denied that this instrument is only of limited application, especially as regards the compass bearing of the inclination, it must be seen that in certain cases very valuable information can be derived from it which otherwise would be unattainable.

PRACTICAL WORKING OF THE INSTRUMENT.

The instrument has only been practically tried in five boreholes, viz.:—in the borehole Sirius, near Crefield, Tellus by Uerdingen, and Berggeist, all of which were put down by percussion boring. The borehole Sirius gave at a depth of 890, 1,100, and 1,230 feet, an equal inclination from the perpendicular of three degrees, with the bearing W.S.W.

The borehole Tellus, at depths of 750 and 796 feet, an equal declination of 11 degrees N.W.

In the borehole Berggeist at 600 feet, the inclination was $4\frac{1}{2}$ degrees.

In the summer of 1874, the borehole Gustav Adolph, near Dienslaken, bored with a turning borer, was stopped at the depth of 750 feet, with the intention of proceeding with it at a future time, and was tubed all the way. This borehole was experimented on with the instrument, and gave the following results:—

At a depth of	200 feet	...	...	...	2°	inclination.
„	300 „	...	...	...	$3\frac{3}{4}$°	„
„	430 „	...	...	...	$8\frac{1}{4}$°	„
„	750 „	...	...	...	47°	„

After this it was decided not to proceed with the boring.

The most interesting experiment made with this instrument was made in the deep borehole bored by Mr. Fiscus, near Lieth, in Holstein. The results were as follows:—

1.—At 328 feet the borehole was perpendicular.
2.—At 656 feet it had a visible inclination, which at 984 feet rose to three degrees.
3.—At 1,640 feet the inclination was small, but at 2,624 feet it rose to one degree, and kept at that to a depth of 3,280 feet.

Two experiments were made with the compass at 1,640 feet and 2,296 feet, the first of which showed a bearing of N.N.E. and the latter N.N.W.

As regards the impermeability to water of the instrument, the following experience was gained:—When hard or soft gutta-percha was used, it proved ineffective at a depth of 1,312 feet; but when varnished paper was used at a depth of 3,280 feet, no water was found in the instrument.

The diameter of the instrument is about three inches, and could therefore only be used in a four-inch borehole.

By means of new boreing machines (diamond boring, for instance) smaller holes can be bored to greater depths.

For such boreholes an instrument has been constructed, with a diameter of two and a quarter inches, which can be used in a three-inch borehole.

In conclusion, the writers may say that by the time the discussion of this paper comes on, they hope to be in possession of the instrument, and to have made a series of experiments with it.

The PRESIDENT, referring to the admission that there were errors observable in the direction of the needle, and that only the mean of a series of observations was recommended to be taken, wished to know if these errors might not all be in one direction, which would render any average taken from them unreliable also?

Mr. D. P. MORISON, referring to the description of the borehole, which, when tested by the machine, was fairly perpendicular for some 300 feet, gave subsequently an inclination from the perpendicular of 8¼ degrees at 430 feet, and 47 degrees or rather more than half a right angle at 750 feet, thought that there must have been some cavity in which the instrument had entered and fallen on its side, for it was inconceivable that it would have been possible to have bored a hole at this angle by any of the appliances in use in this country. He noted that the hole was stated to have been tubed for some distance, but possibly the instrument might have gone further down than the extent of the tubing, and then took its inclination. He also considered it most important to ascertain how far the true direction of any deviation from the perpendicular might be read by the means suggested. He thought that the question as to determining the perpendicularity or deflection and the amount and direction of such deflection, if any, of boreholes, a most important one, and well deserving the serious consideration of the Institute; and he thought that the authors of this paper deserved the thanks of the members for bringing the subject under their notice.

Professor HERSCHEL said, he thought all the difficulties likely to arise from the instrument getting unduly displaced in cavities in the strata would be prevented by using it with rods of such strength as would keep it true with the general direction of the hole.

Mr. H. LAWS stated, that he considered the parties interested were very wise in abandoning the Gustav Adolph hole, and thought it strange

To illustrate Mr. Bunning & Mr. Guthrie's paper "On an instrument for ascertaining the inclination & direction of Bore-holes."

Fig. 1.

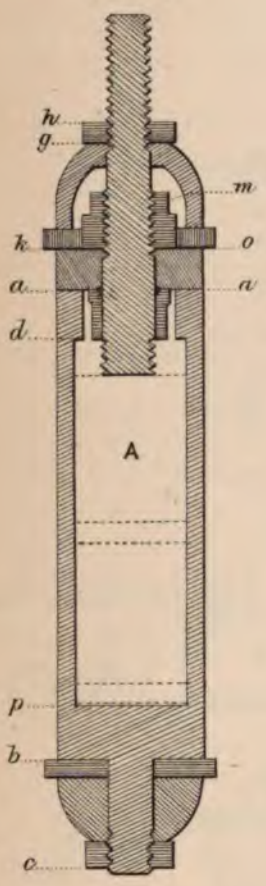


Fig. 2.

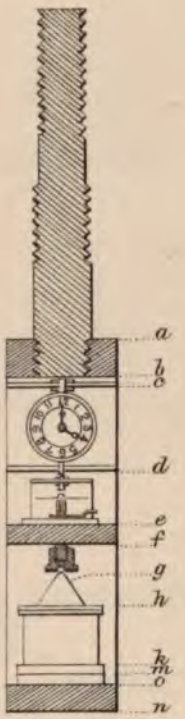


Fig. 3.

Fig. 4.

Fig. 5.

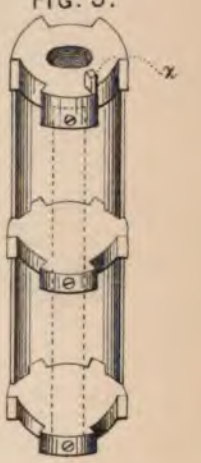


Fig. 6.

Fig. 7

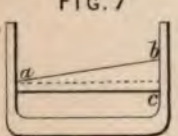


Fig. 8.

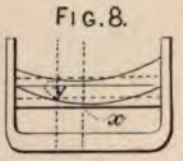


Fig. 9.

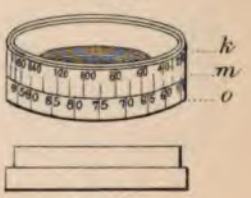


Fig. 10.

Lith. Davis Newcastle

To illustrate Mr. Bunning & Mr. Guthrie's paper "On an instrument for ascertaining the inclination & direction of Bore-holes."

Fig. 1.

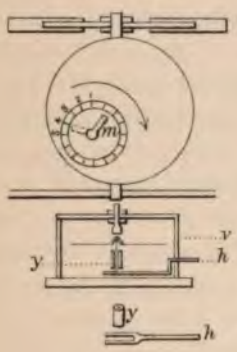


Fig. 2.

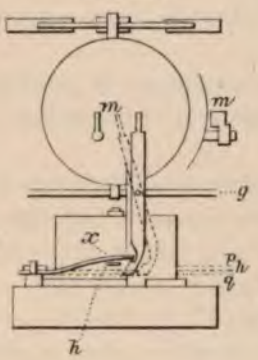


Fig. 3.

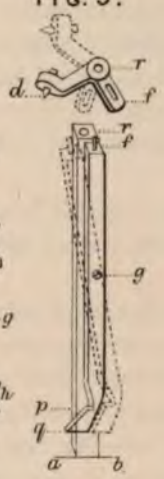


Fig. 4.

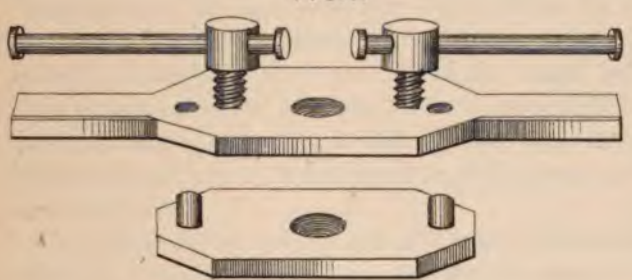


Fig. 6.

Fig. 5.

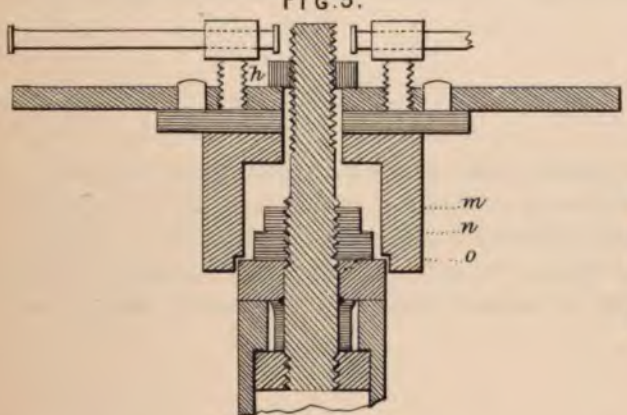
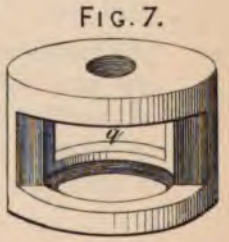


Fig. 7.



Anderson Reid, Newcastle.

that the practical difficulties they must have experienced in making it at such an extraordinary angle had not compelled them to do so before they had tried it with the instrument.

Mr. E. F. Boyd said, that upon first consideration it did seem rather strange that a borehole should deviate so much as 47 degrees from the perpendicular in so short a distance, but the boring rod might have encountered some obstacle during its descent, such as a nodule of ironstone, or some other very hard substance, which had turned it from the right direction, and he thought the interest of the paper would be very much enhanced if Mr. Bunning could obtain some information as to the nature of the strata gone through.

Mr. D. P. Morison thought that if the diagram of the glass vessel which contained the liquid was correctly drawn it would scarcely indicate so great an angle as 47 degrees.

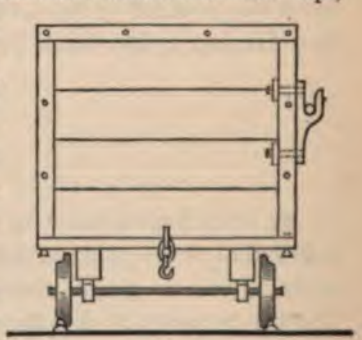
Mr. C. Z. Bunning, in reply, stated, that with regard to the variation of the needle in the tube he thought that from some observations he had made, assisted by Professor Herschel, an average of several observations would give trustworthy results. The extreme divergence of 47 degrees shown in a borehole, which was alluded to in the paper, did seem very unaccountable; but he could give no further explanation of it, nor could he give the nature of the strata gone through, or any further particulars. The diagram of the vessel containing the liquid was not drawn to scale, but even if it had been, the water would have preserved its true level although it might be above one side of the vessel, and although the angle certainly might in this latter case be more difficult to arrive at, it was by no means impossible to find it. He hoped, however, to be in a position to answer some, if not the whole, of the questions when the paper was discussed.

Mr. Morison then moved a vote of thanks to the authors of the paper, which was seconded by Mr. Laws; and the discussion of the papers on Rope Haulage by Mr. James Pease and Mr. W. Jackson was commenced.

Mr. John Brown stated (in a communication read by the Secretary) with regard to the paper on rope haulage, that seven to eight years ago, whilst he was the general manager of the Cannock Chase Collieries, he found it necessary to introduce a system of underground haulage at one of those collieries, and gave much attention to the best mode of

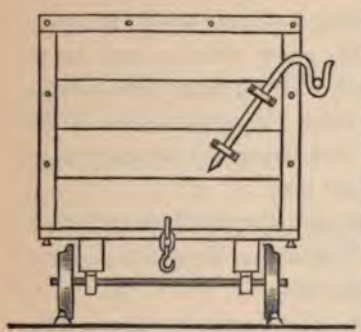
attaching pit tubs to the endless rope. After explaining his views generally to Mr. Jackson, the mechanical engineer at the collieries, he instructed him to visit certain other collieries to see what was being done, and then to work out the detail for some plan of attachment for running a number of tubs together and not singly; the result being that he (Mr. B.) had laid before him for his approval the mode Mr. Jackson had described, and which was found a very satisfactory one for the work required. At first he had fully resolved to adopt the "endless chain" system —running single tubs in the manner so economically adopted originally in Lancashire, and which is so fully described in Vol. XVII. of the Transactions of this Institute—but he was very much disappointed to find, when going most fully into the matter, that on account of the tubs being raised a great height above the top with the large "handpicked" coals of the district, there appeared to be insuperable difficulties in the way of the "endless chain." Where the coal is small and will not admit of the tubs being loaded above the level of the top, he was still of opinion that the "endless chain" will be more economical than either of the inventions under notice; but that each of them possesses merits of its own, where the coals must necessarily be loaded above the top of the tubs. He (Mr. B.) stated that Mr. Pease's invention was in such cases of great value, and he hardly thought it open to the objections made to it by Mr. Jackson, whose clip is also very valuable for the particular work it has to do, but there are cases where Mr. Pease's clip can be used with much greater advantage; he was desirous of seeing its merits fully investigated, as he thought there was greater scope for its use in running single tubs than in running train loads, although in some instances the latter may be more effectual. He thought that a full discussion at the meeting would be beneficial to both gentlemen, as giving them the opinion of practical men.

The PRESIDENT said, that where the tubs were loaded over their tops, and where it was inconvenient for the chain to pass over them, he had seen a small attachment made on the sides of the tubs, as shown in the woodcut, No. 1, answer the purpose of drawing the tubs perfectly—the chains running by the sides of the road—which he thought was also an advantage.



No. 1.

Mr. GRIFFITH stated that clutches or "crooks" for attaching tubs singly to an endless rope by lateral deflection of the



No. 2.

rope, on the same principle as the one mentioned in the paper, worked better with the rope at the side of the tubs, like the endless chain just described by the President, than with the rope over the top of the tubs. He had seen these clutches or crooks (see woodcut No. 2), with the rope at the side of the tubs doing very well. There were, however, two defects inseparable to all these schemes for attaching the rope to the side; that is, first, that the tubs would only go round curves which lead towards the side on which was the rope; and, second, that the side friction on the rails was excessive, and rendered it necessary to keep the road in very good order to prevent the tubs getting off the rails. At one colliery he had seen the first difficulty overcome by sending the tubs back through separate workings in what was termed a "circuit," so that they always went one way.

Mr. T. Lindsay Galloway said, that he had seen a very excellent mode of setting away trains of some twenty tubs by endless rope in Scotland. A small tram for the set-rider was placed in front of the set, provided with a clip somewhat like the one described by Mr. Jackson. When everything was ready, the rider got into his tram and lifted the rope, which was continuously travelling at a considerable speed, by means of an iron hook into the clip, which he then screwed up at his leisure; he could also detach the set at any part of the line by slacking the screw without either stopping or slacking the rope for a moment.

Mr. E. F. Boyd stated that the system mentioned by Mr. Galloway was employed at a colliery at East Tanfield, where a small platform for the set-rider was placed in front of the train, but this plan would not answer for single tubs.

Mr. Griffith said, he had seen the principle, and thought the expense of the riders an objection to it. In one case that he knew of ten riders were only bringing out 500 tons of coals a-day in sets of fifteen tubs, and he thought that there was no advantage in having sets as against single tubs; and if it were urged that there was an inconvenience in detaching single tubs when they were running fast, he would answer that they should not run fast, for it was much more advantageous in all respects to run slowly.

Mr. J. G. Weeks said, he thought that the screw clutch was superior to the clip. No matter where the clip was placed it always was open to

the objection of spoiling the rope by deflecting it sharply and by gripping it with so small a surface; whereas with the screw clutch a very much larger surface of the rope was compressed, and the sharp bend almost entirely done away with; in addition to which the screw action of the latter would be more reliable and effective in resisting the necessary wear and tear than the sliding collar or hoop of the clip.

Mr. D. P. MORISON stated that he had seen the clutch described by Mr. Griffith in use at St. John's Colliery, Normanton, about fifteen years ago, and he believed it was still at work there now.

Mr. PEASE stated that he had had considerable experience both with Mr. Jackson's screw clip as well as with the vertical clip described by himself; the former he found would stand a frictional strain of about 8 cwts., and is usually worked with a small set of four tubs, each carrying 14 cwts.; a second clip is required at the end of the set should the road be undulating. The clip alluded to by Mr. Galloway was much more powerful, being equal to about 15 cwts., and could be used for large trains of 10 or 20 tubs, according to gradient. He considered that the clip of Mr. Jackson stood midway between this and the vertical one he had described.

The meeting then terminated.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, DECEMBER 6TH, 1879, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

A. L. STEAVENSON, ESQ., IN THE CHAIR.

THE SECRETARY read the minutes of the last General Meeting and reported the proceedings of the Council.

The following gentleman was elected:—

ORDINARY MEMBER—

Mr. JOSEPH POTTS, Jun., Architect and Surveyor, North Cliff, Roker, Sunderland.

The following were nominated for election at the next meeting:—

ORDINARY MEMBERS—

Mr. EDWARD GAWLER PRIOR, Government Inspector of Mines, Nanaimo, British Columbia.

Mr. WILLIAM FREDERIC BUTLER, Civil Engineer, 6, Queen Anne's Gate, Westminster, S.W.

Mr. WILLIAM ACKROYD, Jun., Morley Main Collieries, Morley, near Leeds.

STUDENT—

Mr. R. CECIL PEAKE, Harton Colliery Offices, South Shields.

VISIT TO THE WORKS OF MESSRS. BLACK, HAWTHORN, AND COMPANY, GATESHEAD.

DECEMBER 6TH, 1879.

By the kind permission of Messrs. Black, Hawthorn, and Co., of Gateshead, the works belonging to that firm were open for inspection to the members, and a large number availed themselves of the opportunity. They were received by Mr. Hawthorn, who conducted them over the works, and also exhibited and described to them the new tram locomotive invented and patented by the firm. It has been designed and constructed for street tramway traffic, and is very short and compact, with the object of convenience in working in crowded thoroughfares. It is also constructed according to the Board of Trade requirements in respect to absence of steam, smoke, and noise, whilst working. The form of the locomotive resembles that of a tramcar, the idea being to avoid frightening horses, and there is no part of the working machinery visible. The engine is carried on four wheels, all coupled. It is on the compound principle, the same steam being used twice over. It is also direct-acting, being coupled direct to the axle. The sizes of the cylinders are 7 and 12 inches in diameter, and the stroke 11 inches. The wheels are 2 feet in diameter, with 4 feet centres. The boiler is of the ordinary locomotive type; it has a copper fire-box and brass tubes, and is arranged for burning coke with the natural draught of the chimney. The working pressure is 150 lbs. per square inch. To avoid the appearance of steam, the exhaust steam from the low-pressure cylinder enters what may be called a receiver, in which it is expanded, and from that enters the condenser. The chief feature of the engine is the means for condensing the steam. It is an improved air-condenser, the construction being similar to that of a saddle tank, having upright sides upon it, between which are fitted a great number of small tubes. The condenser in working order is kept nearly full of water; and the steam from the low pressure cylinder, after passing through the receiver, enters the condenser at the bottom, through cones, and the steam meeting the water is condensed, and, at the same time, the effect is to cause the whole of the

contents of the condenser to circulate through the tubes and to become cold by coming in contact with the great radiating surface provided. The temperature of the water does not much exceed 180 degrees Fahr. in summer weather and 100 degrees in winter; but if it is kept below the boiling point it still performs its work. The small amount of vapour which may come from the water passes into the chimney along with the hot air from the boiler, and is invisible. That being almost the only waste of water, the engine is able to run for a long period without taking in an additional supply of water. It is obvious that the question being merely one of amount of cooling surface, the area might be increased so as to enable the engine to run for any specific time. The arrangement of the condenser has been patented by the firm. The fuel used is coke, from which there is no escape of smoke, and the quantity used is only about 4½ cwts. in the twelve hours. This small consumption of fuel is no doubt attained by the adoption of the compound system of engine combined with the form of the condenser, as the feed-water is supplied to the boiler hot, and at the trial the engine had ample steam power. The engine has been inspected by the Board of Trade, and to meet one of their requirements is fitted with a speed indicator and governor. During the trial to-day the engine travelled at the rate of eight miles an hour, steadily, smoothly, and almost without noise, and with no smoke or steam visible. It was completely under control, and was stopped with the steam-brake in a distance of 10 feet from a speed of six miles an hour. In other experiments the engine has taken two loaded tramcars up a gradient of 1 in 20 with ease; and it is obviously capable of much more than would ever be required of it in the working of tramcars. The engine was under steam for upwards of four hours to-day without showing steam or the water being changed. There was but one opinion amongst the visitors, namely, that the results were extremely satisfactory, and that the engine is well adapted for the purpose for which it has been designed.

It occurred to several of the visitors that the same principle of the compound condensing engine could be arranged for use in coal mines, where the ventilation is tolerably good. The heat from the engine would not affect the temperature of the air to any appreciable extent, and the height of the engine could be made suitable for passing along the workings.

After seeing the working of the tramway engine, the visitors were shown through the works in which are a number of locomotives of different kinds in progress, two of which are being built for a glass manufactory on the Tyne. They are being built very low, with the object of enabling them to pass under archways about 7 feet in height. They are to be

employed in bringing sand from the sea shore to the works, each drawing a train of tip wagons. They are extremely compact, substantial, and handy engines, and well adapted for their special work. Several other engines are also being built for use in iron works to the order of a firm upon the Tees.

After returning to the Hall, the following paper, "On the Extraction of Oil and Ammoniacal Liquors in Coking Coal in Ovens," by Mr. HENRY AITKEN, was read :—

THE EXTRACTION OF OIL AND AMMONIACAL LIQUORS IN COKING COAL IN OVENS.

By HENRY AITKEN.

In a paper by the writer, which appeared in Vol. XXIV., page 97, of the Institute Transactions, on the working of his blast coking oven, it was stated that several pailfuls of tar and ammoniacal water had in some cases been taken from a single oven, but that the quality of the coke had always suffered; and the first object of the present paper is to correct this statement, for not only has it been found to be incorrect, but it may be now confidently stated that the coke made—when the tar or coal oils and ammoniacal water are taken off—is more dense and in larger pieces, while the yield is increased about 1½ per cent., and further, that some of the dry non-caking Scotch coals make a fair coke in this manner of working that will scarcely make coke at all when coked even in the blast oven in the usual way.

In order to carry on the coking in the blast oven while at the same time taking off the oils and ammoniacal water, three flues are made in the bottom of the oven, about 4 inches square (G G G), Plate V., Figs. 1 and 2, and these are covered with tiles having perforations about ¼ inch diameter at top and 1 inch diameter on the under side. These three flues meet in one near the door, and into this flue the pipe (H) is inserted which is connected to the condensers. The condensers may be of any shape, but it is necessary that a mechanical exhauster or steam jet should be in connection with them in order to assist in drawing the gases from the oven.

The oven is worked in the following manner:—The oven having been filled with coal is allowed to kindle; the blast is applied, and after a considerable heat has been raised (which generally takes about three hours), the top exit from the oven is partly closed, so as to bring a pressure of about 2-10ths of an inch of water on to the gases in the top portion of the oven. The pipe is then connected to the condensers, so as to take the gas off from the flues as before mentioned. The steam-jet exhauster

in the condenser is put into operation and brings a partial exhaust on to the bottom of the oven of a little over 2-10ths of an inch of water, and this state of matters is continued until the oven has worked itself off. When the pressure and exhaust are so regulated, gas rises from the coal sufficient in conjunction with the injected air to carry on the process of coking. For the first twenty-four hours the temperature of the gases issuing from the bottom of the oven is 300 degrees Fahr. In the next twelve hours the temperature is gradually increased to 600 degrees Fahr., and in other twelve hours to 1,000 degrees Fahr., as shown by the following table:—

Date.	Time taken.	Temperature of Gases on leaving Oven at bottom.	Strength of Suction on Bottom of Oven.	Pressure of Gas on Top of Coke in Oven.	Pressure of Blast entering Oven.
1879.		Degs. Fahr.	Per Inch of Water.	Per Inch of Water.	lb. per Square In.
September 5 ...	7 p.m.	300	·25	·2	1
„ 6 ...	6 a.m.	300	·2	·3	1
„ 6 ...	6 p.m.	600	·225	·2	1
„ 7 ...	6 a.m.	1,000	·05	·1	1

This table, it will be observed, also shows the varying exhaustion or suction at the bottom of the oven, the pressure of the gases on the top of the coke, and the pressure of blast going into the oven.

The time taken to work off an oven in this manner of working is about from 15 per cent. to 20 per cent. greater than when working the blast oven in the usual manner.

The permanent or non-condensed gases made are allowed to issue at present from the end of the condenser pipe, and are there burnt for light. Their illuminating power is not great, but they are used for lighting up one of the engine houses. The intention, however, is that these gases should be forced into the oven again above the level of the coke, and there used to create heat to carry on the coking. Unfortunately the steam jet hitherto used on the condenser is not of sufficient power to accomplish this, and consequently the quantities of oil and the strength of the ammoniacal liquor got are much less than otherwise they would have been. In addition the quality of the oil or tar obtained, it is considered, suffers in like manner, as no doubt it will be the light gases that rise up and support combustion, and these gases if condensed would form light oils. The oven should be provided with a proper exhauster, having sufficient power to draw

the gases from the bottom of the oven and force them into the upper portion of the oven after having been deprived of the oil and water through the pipe F. A scrubber should also be used, in order to secure the ammonia now passing off with the gas.

The results obtained have been realised with apparatus far from perfect, but, from the novelty of the manner of working, they are of some interest.

The largest quantity of oil got per ton of coal charged into the oven was 11 gallons, the specific gravity of the oil varying from ·925 to 1·000. For the reason which has been stated, the gravity of these oils would be much decreased if a more perfect exhauster and condenser were applied, and the quantity would also be increased.

The oil obtained may be described as an oil the lighter portions of which are well suited for torch or lamp oil, the heavier portions, which contain a large percentage of creosote compounds, being suitable for preserving wood, such as railway sleepers, etc. It contains also a small quantity of paraffin scale. These oils are at present being tested for the purpose of ascertaining to what extent in the manufacture of gas from common coal they will increase the illuminating power of the gas. When the oil is distilled there is only a loss of 1 per cent.

The usual quantity of ammoniacal liquor obtained is about 30 gallons per ton of coal, and the specific gravity is 2 Twad. This, however, does not represent correctly the amount of ammonia in the liquor. One sample tested was taken from the working of six ovens, and the analysis showed that it contained 174 grains of ammonia per gallon of water, or equal to 9·7 lbs. of sulphate of ammonia per 100 gallons. Another sample has been tested and found to contain nearly twice this amount or fully 5½ lbs. sulphate to the ton of coal coked. The quantity of ammoniacal water got per ton of coal charged is in excess of what is in the coal, the excess being derived from the water put in to cool the coke of the previous charge, and converted into steam as the coking proceeds. It is certain that the quantity of ammonia would be much increased if the exhaust and condensing apparatus were more complete.

To show the difference in the quality of coke made by the blast oven, with and without taking off the oils and waters, samples are submitted for inspection. There are also submitted samples of the crude oil and ammoniacal water and samples of the semi-refined oil and parafin scale.

This will probably be considered as not the least successful effort that has been made to utilise the oils and ammoniacal water in the manufacture of coke, while at the same time there is the largest possible yield of coke,

in almost every respect equal to that produced from an ordinary beehive oven, the coke made from which, probably all are now agreed in thinking, is the most suitable coke for all purposes.

Samples of the coke and the various substances mentioned in the paper were exhibited.

Mr. T. LINDSAY GALLOWAY thought it would add to the value of the paper if the class of coal from which the coke was made was more particularly described, and if an analysis of it were given.

The CHAIRMAN thought that it would be a great advantage if Mr. Aitken could give them, when the paper was discussed, some idea of the commercial value of the arrangement. There had been various attempts made before to utilize these for oils, etc., and there had been a paper on the subject read before the Institute. Messrs. Bell Brothers, in this district, had expended some £3,000 in endeavouring to carry out what Mr. Aitken seemed to have succeeded in doing, and he thought that it remained with that gentleman to show that his invention had proved a commercial success. In the system experimented on by Messrs. Bell Brothers there were no retorts and no artificial blast or exhausts; the gases were simply drawn away by the ordinary drafts of the chimney passed through a long length of pipes, and the ammonia and tar received into wells below, whilst the gases were returned to the bottom of the oven to carry on the coking process.

Mr. D. P. MORISON asked what time the coke took to burn, as the tables did not convey any very clear impression on the subject?

Mr. COCHRANE bore testimony to what had been done by the Chairman, who had, after his very great experience upon the subject, come to the conclusion that the expense incurred was not covered by the results obtained, and had come back to the ordinary beehive oven.

Mr. COXON desired to know the difference of yield between Mr. Aitken's ovens and those in common use?

Mr. AITKEN, in replying to the various questions addressed to him, stated that he would endeavour to give analyses of the coals used when the paper was discussed. One of the samples of coke exhibited was made from a coal that the vendors admitted they could not make into coke in the ordinary beehive oven. The yields of coke from the patent oven were given in the paper before referred to, and, as already stated, the yield of coke when taking off the oils was 1½ per cent. greater than when the whole volatile matters were consumed in the oven; so that the yield of

To illustrate Mr Henry Aitken's paper "On the extraction of Oil and Ammoniacal liquors in Coking Coal in Mines."

FIG: 1.

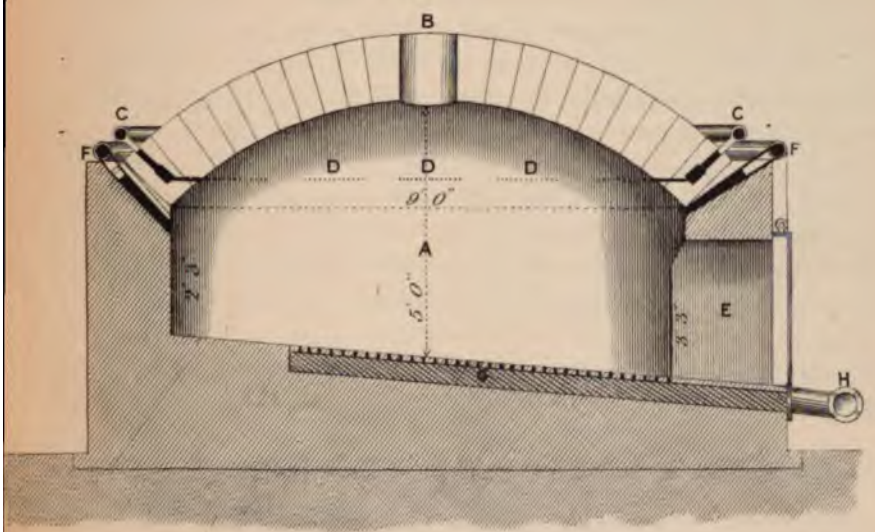
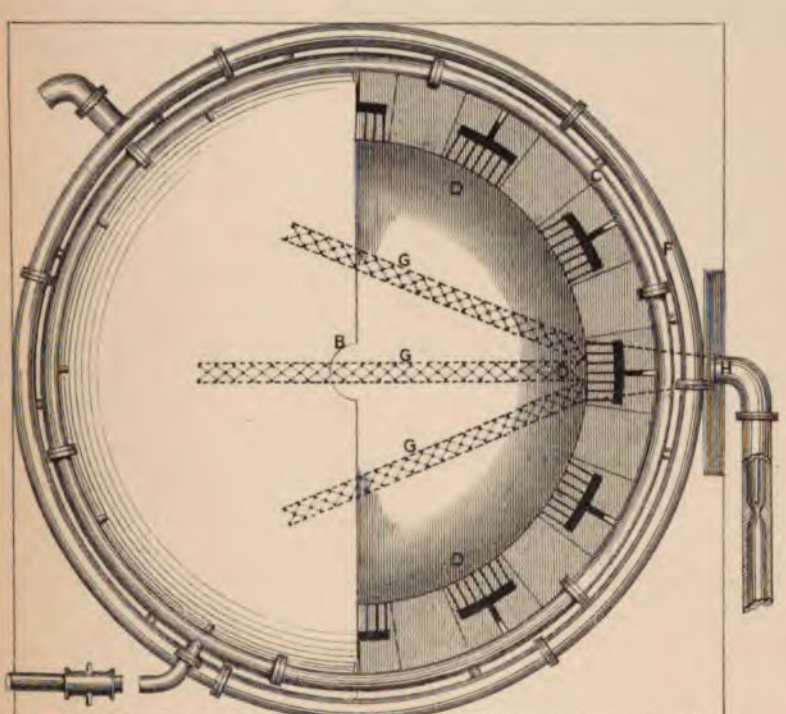


FIG: 2.



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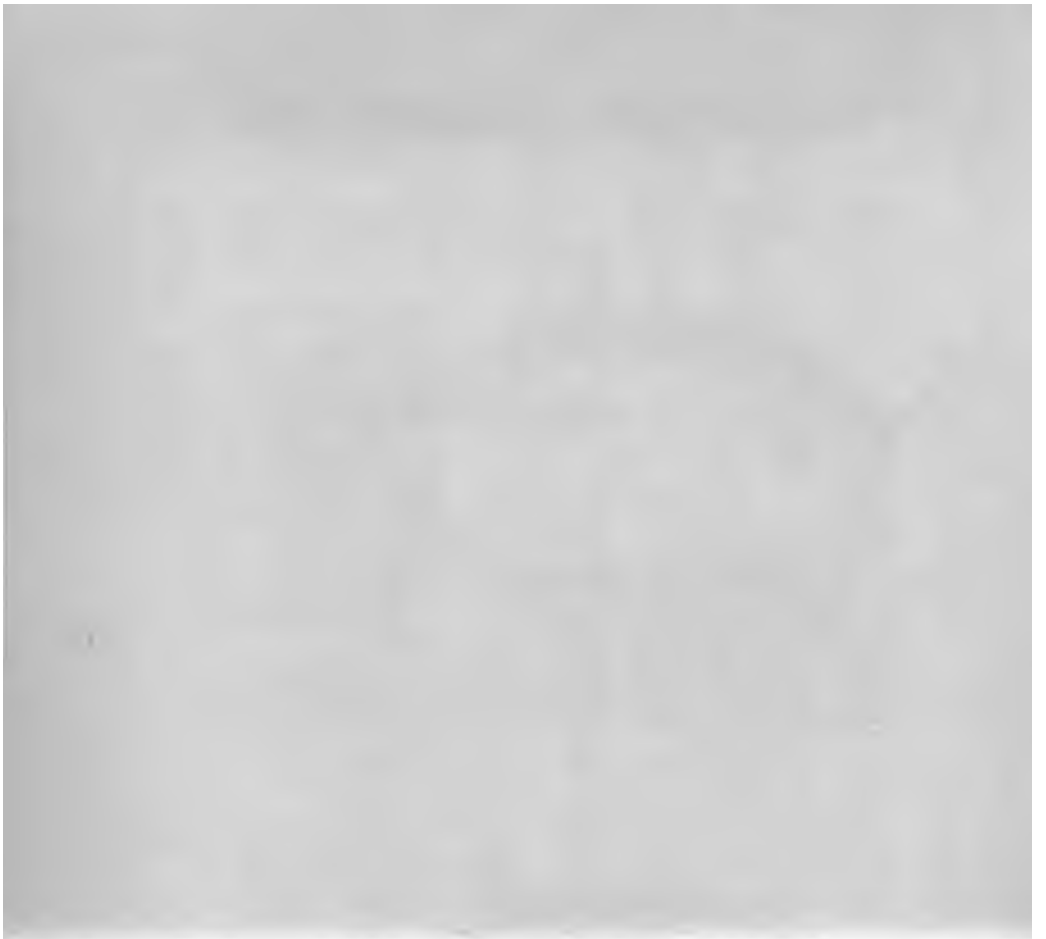


coke when the gases were taken off and condensed was within 2 per cent. of the yield that could be got from the same coal when coked in a retort, by which mode few Scotch coals give a yield of more than 64 or 65 per cent. So far as he knew, all the systems previously attempted for collecting the ammonia and tar had been tried with retorts or ovens of that description, and the Chairman's remarks corroborated this view. The temperatures given in the table were taken by Siemen's pyrometer, at Blaenavon, where the blast ovens are at work. The total time the coke was in the oven was forty-eight hours when not taking off the volatile products; whereas without the hot blast they took seventy-two hours; but means were provided for prolonging or hastening the process as might be from time to time deemed expedient. As stated in the paper the increased time taken to coke coal, at the same time taking off and condensing the volatile products, is from 15 to 20 per cent. above the time taken with the hot blast oven in the ordinary manner.

The CHAIRMAN stated that he had much pleasure in proposing a vote of thanks to Mr. Aitken for his valuable paper.

Mr. D. P. MORISON seconded the proposition, which was unanimously carried.

The following paper, "On Boiler Accidents and their Prevention," Part III., by Mr. D. P. MORISON, was read :—

ON BOILER ACCIDENTS AND THEIR PREVENTION.

By D. P. MORISON.

PART III.

ON THE SETTING OF BOILERS AND BOILER FLUES.

Before entering on the main features of this, the third part of the subject, the writer proposes to review to some extent the general conclusions to be drawn from the previous heads touched upon. These were so arranged as to bring up by successive stages the various modes of effecting additional security to steam users; as well as the results obtained by the different societies or associations founded for the purpose of increasing independent and trained inspection. Inspection by official or Governmental means was also briefly alluded to, and in further elucidation of this theory the following appropriate extracts may be quoted:—

(a.)—Opinions of Managers of Independent Insurance Companies.

No. 1 very lucidly gives his views on the subject:—

My further experience of inspection and in the investigation of explosions has convinced me that the suggestions made to the Select Committee in 1870 would be productive of great good (whilst such a course would not interfere with the freedom desired by engineers and steam users, and to which great value is attached in this country), *i.e.*, compulsory registration of all the steam boilers in use, and an annual return to be made stating by whom the boilers are inspected, the owners to be responsible for the choice of the parties engaged to inspect.

I think insurance is of great value to steam boiler owners, as they are exposed to considerable loss and risk through negligence of their men, however well their boilers may be made and fitted up.

One Association for the Prevention of Boiler Explosions *inspected only*, for many years, the result being, as they were not responsible, the work was badly done. I do not think any insurance company, having a pecuniary liability in case of explosion, has ever inspected so badly as this association did until they adopted the partial system of insurance which they denominate "guarantee." This gave them a power over boiler owners which they never possessed; whilst their own responsibility has induced them to make such arrangements as to secure better inspection.

A boiler census would be of great value statistically, but, if the system of registration referred to were adopted, of course the numbers could be obtained with further arrangement.

If each explosion, whether fatal or not, w re reported upon in a simple manner, it would be advantageous; but there is a danger of "red tape" creeping in, and leading to the inquiry being unduly elaborate and expensive. If such a course were adopted all steam users would have to be laid under a penalty should they fail to report an explosion; otherwise those alone which were under responsible inspectors, would be likely to come to light unless some one was killed.

Steam boiler owners should certainly be held under greater responsibility than at present. The great ignorance and recklessness evinced in many cases is proof of the importance of alteration of the present laws relating to the employment of steam.

We find the greatest difficulty is the apathy or ignorance respecting inspection and what is necessary or satisfactory. Even so-called first-class boilermakers and engineers will set up boilers, or permit them to be set up, with excessively broad seatings, inaccessible flues, or other hindrances to inspection, which really lead to a waste of fuel instead of economy.

We are often pretty roundly abused because our inspectors complain of the deficient or faulty preparation, mud, dirt, and scale being deposited on the plates or in the external flues; but should inspectors under such circumstances overlook a defect, there is as much outcry as if everything had been laid open as clearly as possible to him.

I think any regulations that are made should provide for the boilers being so arranged that satisfactory inspection can be made, otherwise many explosions would still occur through the inaccessibility of some parts of the boilers.

No. 2 expresses himself to this effect:—

That the less Government has to do with matters of this kind the better.

No. 3 says:—

I don't see how any harm could possibly be done by having a census taken of all the boilers in the kingdom. It would be useful to show the percentage of explosions which cannot otherwise be ascertained accurately, and might help to decide whether or not the Legislature ought to interfere.

A record of every explosion, whether fatal or otherwise, would also be useful to those who take an interest in the subject, but these I believe form a very small number. When a boiler explosion occurs there is great excitement amongst those in the immediate neighbourhood, but it soon subsides, and the affair is forgotten, or at least little thought of.

As to the third question I think that some companies "take too much risk by the desire of profit," for in several instances I have known boilers insured by other companies which I had refused on account of their being in my opinion unfit for the pressure required. But the same objection may be made to inspection without insurance, while it may be said in favour of insurance that the pecuniary liability involves responsibility which will insure more efficient inspection.

I am no advocate for Government inspection, but still hold the same opinion as I gave before the Select Committee, that a similar investigation should be made in regard to every boiler explosion as in railway accidents, by a competent Government officer,

who should call whatever witnesses he might think proper; and in cases of culpable negligence, either on the part of the owner of the boiler or of the attendant, a prosecution and punishment should follow. A few examples of punishment would prove the most effectual means of preventing explosion by inducing the owners to have the boilers periodically inspected.

No. 4 gives as his opinion :—

What we recommend in the way of Government action in regard to the prevention of boiler explosions is, that, in the first place, it should be enacted that every boiler shall be periodically inspected. This inspection, however, should not be undertaken by the Government but should be entrusted to voluntary associations of steam users, such associations being authorized and registered by the Government.

We think it desirable to ensure the efficiency of the inspectors that the commercial element should be eliminated, so that the inspection should be undertaken in the interest of the public safety and not for pecuniary gain. Commercial rivalry and sound inspection scarcely harmonize.

We also urge that a searching investigation (by a competent and independent court of enquiry) should be made in the case of every explosion, whether fatal or not, so that if the inspectors were in the wrong the blame might be thrown on them. This would tend to purify the inspections.

Nos. 5 and 6 suggest increased facilities for insurance and inspection companies, and greater powers granted to their inspectors, both in reports and in evidence before juries.

No. 7 curiously veers round from his past published opinions and reports, and now urges :—

Every boiler should be examined internally and in the flues once every year, and it is very generally supposed that insurance companies will inspect boilers insured with them, in their own interest. But this idea is fallacious. A joint-stock company is formed for the purpose of profit and not for philanthropy, and it actually costs more to make competent inspections than it does to let boilers burst and pay compensation. A short calculation will make this clear. In the first place it is necessary to get at the risk of explosion, and to do this we must see what is the number of boilers in the United Kingdom, and how many of these burst every year. It was stated before the Parliamentary Committee which sat in the year 1869–70 to investigate the causes of steam-boiler explosions that there were about 100,000 boilers in the United Kingdom, and this estimate was generally accepted, though some thought it too low, while our records show that fifty explosions occur year by year. Dividing the number of boilers therefore by the number of explosions, we find that one boiler in 2,000 bursts every year, or that the risk of explosion is one for every 2,000 boilers. If, therefore, an insurance company insure a boiler for £100, as in the case of the one at Halifax, their risk will be one two-thousandth part of that £100, which amounts exactly to one shilling; so that the net risk is only one shilling per cent. Now, to make "thorough" examinations of boilers to prevent explosions is very expensive. The inspector has frequently to be sent many miles from the head office, thus incurring the expenditure of time as well as of money in travelling. On making his inspection he has to get inside the boiler and also to pass through the flues, examining the boiler in all its parts as well as the

fittings. Further, he has to gauge the thickness of the plates, ascertain what alterations or repairs have been effected since the last visit, and if the boiler has been but just enrolled he has to take full particulars of its construction and accurate dimensions. On returning to head-quarters he has to make a complete sketch, giving the thicknesses of the plates, etc., while he has also to draw up a report on the condition of the boiler, faithfully pointing out all its defects. When this is done the whole has to be checked and considered by the chief engineer or his assistants, and the owner communicated with thereon; this communication giving full information of the precise condition of the boiler, and making such recommendations as may be found necessary. At our office are filed carefully prepared drawings of all the boilers enrolled. These are at all times open to the inspection of the members, who frequently avail themselves of this opportunity when contemplating alteration to their boiler plant. It will be seen at once that such a work must be expensive. Including the inspector's time and travelling expenses, as well as a fair charge for the services rendered by the chief engineer and his staff in the office, it is calculated that every "thorough" examination costs on an average not less than 20s. This is simply for the annual "thorough" examination, and does not include the expense of the external examinations which it is necessary should be made when the boilers are at work, two or three times a year. Thus the cost of insurance is only 1s., while the cost of an annual "thorough" examination is 20s. It is not necessary for this argument that these figures should be absolutely correct. If the number of boilers in the country be greater than 100,000, the risk of insurance will be less, while the cost of the annual "thorough" examination might be estimated by some as more than 20s., and by others as less. It may, however, be taken as a broad principle that the cost of inspection very much exceeds the cost of insurance.

(*b.*)—The Evidence before the Commission.

This is too voluminous to be quoted *in extenso* in the limits of a paper such as this, but the main tendency is to prove that inspection is urgent and necessary, that it should be accomplished by private enterprise (either by mutual or independent societies), and that Government interference, except for investigation or registration, is to be deprecated.

The writer himself is of opinion (and this opinion is shared by competent authorities) that Government supervision of boilers would be useful, and ought to be *imperative*, but only in the following points :—

1.—An exact register should be kept of every steam boiler or vessel in which any pressure above that of the atmosphere is engendered; such register to be kept by any competent body of men, such as assistant-overseers, nuisance inspectors, relieving officers, or other officials whose duties bring them in daily contact with works, factories, or places where steam is employed. This list to be furnished by each parish or township to the Board of Trade.

2.—The register to include dimensions, shape, uses and pressure of each boiler, with name and address of proprietor.

3.—That such register should be supplemented by particulars to be furnished by the inspection companies in cases where boilers are under their charge.

4.—That in the event of any boiler explosion or accident, notice should be given by the proprietor to the Board of Trade, through the parties named in clause 1; and that in case of any inquest being held, full particulars of such inquest should be sent to the Board of Trade.

The mode in which such register should be kept, and the number of times in which the figures should be revised, will naturally be matters for consideration, and a very important and proper topic for discussion by the members of this Institute, who have under their care such a large proportion of the steam generators in use in this country.

It may, therefore, be concluded that the following are the heads to which the attention of the members of the Institute should, so far as the preceding portion of the subject has gone, be mainly directed:—

1.—How may boilers be efficiently inspected?
2.—Does independent inspection offer additional security?
3.—Is Government control of inspection necessary?
4.—Is registration by authority advantageous?

These questions may be left in the hands of those competent to judge; and the writer trusts that in discussion, as well as in further contributions to the Transactions, the subject so imperfectly broached may be extended and rendered still more interesting.

The finding of a jury in a recent case will show how public opinion is now verging towards the writer's conclusions:—

That the jury are of opinion that some efficient action should be taken by the Government to compel the various insurance companies who undertake the insurance of steam boilers, to insist upon a periodical and thorough inspection of all boilers and their fittings under their care. That in all cases each boiler should have a separate and independent steam gauge and water gauge.

The writer now wishes to pay a well-deserved tribute to those who have so ably and kindly assisted him in the first parts of his subject; and, amongst others, to Mr. E. B. Marten for his most valuable tables and statistics, and to Mr. C. Z. Bunning for his translations of the reports of the German Societies. Mr. Marten has further assisted greatly in the succeeding topic of boiler-setting by his notes and models, the result of many years assiduous observation; and Mr. James Young, of Lord

Durham's collieries, Messrs. D. Adamson and Co., Messrs. Hawksley, Wild, and Co., and other well-known engineers, have also added their useful experience.

BOILER SEATS AND FLUES.

In the present paper the relative functions of the fire grate as the true generator, and the boiler as the *converter* of heat into steam, may be considered.

In a paper read by Mr. Head, and reprinted by the Midland Steam Boiler Inspection and Assurance Company in 1869, it is stated that one cubic foot of water can be made to give in an hour 2, 2½, or 3 to 4 indicated horse power, according to the engine used, but with the useful effect of the steam the present paper has nothing to do; the possible result of burning 1 lb. of coal may, however, be taken as 16·29 lbs. of water evaporated, but in practice it is only 7·7 lbs.

Mr. Head says—

10 per cent. drops through the bars.
15 per cent. through the nitrogens unconsumed.
10 per cent. want of sufficient heating surface.
18 per cent. escaping gas and radiation and blowing off to jet *via* scale.

53 per cent. wasted.
47 per cent. used in steam for the engine.

100

The remedies he suggests are:—"No stoking but mechanical firing; regeneration, or returning as much heat as possible in the air and water supplied to the boiler; more heating surface, as attempted in the Galloway and Field boilers; and clothing (or covering) and small water spaces."

The present paper is simply intended to treat of the settings most likely to lead to good results.

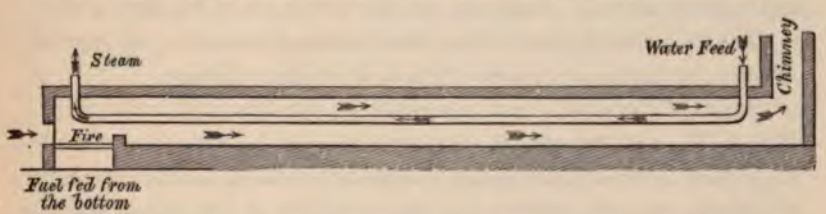
The theoretically best fire grate would be one where combustion was complete, no waste heat escaping to the chimney, and no radiation possible.

If complete combustion were the only object, this could be nearly accomplished by very brisk combustion within a comparatively small chamber, where an intense heat would be so concentrated as to have little area for radiation, and would be somewhat like the electric light which occupies so small a space as to radiate very little.

For steam generation, however, there are other essentials which at once make the near approach to the theoretical duty impossible. The heat must not be so great or concentrated as to permanently injure the boilers; it must always be sufficiently in excess of what is taken up by the boiler, as

it must force its way through the plates, which process takes time and energy, and a large area, therefore there is much chance of radiation; and further, the gases must leave the boiler at a higher temperature than the last part in contact, or they *rob* the boiler of heat; and lastly, they must have heat enough in them to create the proper draught in the chimney.

The best theoretical boiler should be a long pipe of the thinnest possible material placed in a long flue with the fire at one end and the chimney at



the other. The fire is the hottest part and in contact with the hottest water, where it is just about to pass into steam, then flame advances along the flue and leaves when it has given up all its heat except just enough to cause a draught in the chimney, where it meets the water coming in at a low temperature and imparts heat to the last moment.

The feed water thus enters at the coolest part, and gradually advances to the hottest, and meets with increasing heat, without returning to a cooler part to give up its heat again, as is too often the case when types of boilers are used in which so-called "proper circulation" has been provided for, in lieu of the steady advance of the feed from the cool to the warmer portion of the boiler. There are endless objections to this simple example as a practical boiler, but it shows clearly the principles involved, and it will be noted afterwards that the most successful boilers have been those where these principles have been most regarded. To more readily understand the bearing of this example or typical fire grate and boiler it may be well to glance at the most common forms of boilers and modes of setting and compare them with it.

In the oldest forms of boilers, such as the spherical, balloon, wagon, haystack, etc., shown in Figs. 1 and 2, Plate VI., the steam was only needed as a condensing medium, and a very slow, dead fire was enough to maintain the required temperature. Even here great efforts were made to lengthen the travel of the gases by internal flues.

When higher pressure was needed than the balloon and other weak-shaped boilers would bear, the plain cylinder type, as shown in Fig. 2, Plate VII., came into use; this more nearly resembles the theoretic example,

but has the disadvantage of being made of very thick material necessary to resist the strain of pressure in so large a vessel; also there is a large mass of water which circulates from end to end, the whole of which has to be raised to evaporating point before much steam is given off (as in the common sauce-pan), and thus one of the essentials is disregarded.

The extreme difference in the dimensions of some of these plain cylinder boilers is well contrasted in Figs. 1 and 2, Plate VII., where the shortest and longest met with in ordinary practice are shown to the same scale.

The French or elephant boiler, was an attempt to decrease the quantity of water by the use of a series of tubes, or smaller cylinders.

Some of the most recent combinations, like the steel boiler, Fig. 7, Plate VIII., are efforts in the same direction, but in this arrangement the progressive advance of the feed is disregarded, while the Nedderbrun boiler, is a nearly complete realization of the principles of the typical example, for the fire and flame advance in one direction, and the feed water meets them in the opposite direction, and as might be expected the result is great economy of fuel and repair.

The Cornish and Lancashire boilers, Figs. 1 and 2, Plate IX., although deservedly popular for their convenience and efficiency, lamentably fail in the particular of allowing the gases to escape when only a small part of their useful effect is secured, because the circulation renders it needful to have the whole contents at a high temperature before there is much evaporation. This defect has been corrected by the use of small combinations of pipes in the flues called "economisers," to bring back part of the escaping heat, and the combined result is more satisfactory.

The true principle of circulation was first noted in such marine boilers, Figs. 3 and 4, Plate IX., where the spaces between the tubes were so small that the hot water could not return, and where the feed made the steady advance held essential in the typical example.

It was further discovered that the real work of the Cornish and Lancashire boiler was done by the upper part of the internal flues, and that the cool feed remained at the bottom until forced to the top by the entrance of more feed, and that therefore the flues did little good on the outside. Thus these boilers were found in practice to more nearly approach the typical conditions than their advocates were aware of, and hence the very high duty of some of the earlier examples of Cornish boilers.

When the heat is obtained from puddling or other furnaces a special complication is introduced, as in the samples shown in Plates X. and XI., but the same general rules should be observed.

The great advantage of small tubes in allowing of small water spaces and thin material has led to very many samples of boilers, such as the Hancock's, the Howard, Figs. 5 and 6, Plate VIII.; the Root, Fig. 8, Plate VIII.; the Belleville; and the success of these has been various, owing to difficulties of circulation or advance of feed. In the Benson boiler an attempt was made to improve the feed advance and the circulation by the introduction of a so-called "heart" or pump. All these forms suffer from deposit, and that is the reason why Mr. Perkins introduced his boiler (Figs. 1, 2, 3, and 4, Plate VIII.), combined with the engine described at the last meeting, where the same water is used over and over again.

Such boilers as the Crane Boiler are for convenience rather than economy; and the Locomotive has to be made to suit its work without reference to the ordinary principles of stationary boilers.

If economy of *fuel* were the only object sought, the setting of boilers should be contrived to bring the spaces of the flues to just the sufficient area for the draught, so that the reflected heat of the brickwork may aid the general result; and where this has been done, and sufficient boiler and grate room has been provided, the economical result has been very satisfactory. The Cornish boilers thus set in Cornwall so entirely used the heat, from the perfect and slow combustion of the fuel, that the stacks showed few marks of smoke upon them, although whitewashed to the top. Carefully set and worked slowly, as intended when designed, the plain cylinder does good duty, almost rivalling the Cornish boiler; but in practice it is forced to do more in a given time than it can do economically, and the general waste prevails, its duty being only half that of the Cornish.

There are other economies to consider besides the mere saving of coal, as it is possible to attain that and have a ruinous expenditure in other ways.

Where coal is very plentiful and small, or of poor quality, it may be far more economical to save outlay and put up plain cylinder boilers with plain flash flues, but where coal is dear, as in Cornwall, the more expensive Cornish boilers are really the cheapest.

As the need of inspection is now generally recognised, it is found true economy so to construct the flues as to make them easy to traverse with the points of contact with the brickwork so made as to see each seam of the boiler without disturbing it (see Plate XII.) The Figs. 41 to 50 in "Records," pages 82 to 84, have several sketches of the difficulties of inspection, and sketches are attached showing others.

The general result of the usual setting of boilers in common use may

thus be compared, the average practical duty being stated in lbs. of water evaporated per lb. of coal:—

	With Careful Experiments. Lbs. of Water per lb. of Coal.	In Average Practice. Lbs. of Water per lb. of Coal.
Externally Fired Boilers—		
Balloon or Wagon	8 to 9	5 to 6
Plain cylindrical, British tube, etc. ...	8 to 9	4 to 5
Tubular boilers, such as the Howard, Root, Allen, Phleger, Lowe, and Blanchard...	8 to 10	5 to 6
Internally Fired Boilers—		
Cornish or Lancashire	9 to 10	5 to 6
With economisers	10 to 11¼	8 to 9
Locomotive	9 to 10	8 to 9
Marine	10 to 11¼	7 to 10
Multitubular and portable	7 to 8	5 to 6

In reference to the seating (or setting) of boilers one of our most important and experienced colliery engineers thus expresses himself:—

The Lancashire and Cornish Boilers.

It is scarcely necessary to remark that for many years past they (the Lancashire or Cornish types) have been, and are still, great favourites in the manufacturing districts in the South and Midland Counties, and when efficiently inspected and looked after and properly seated, give very good results. The tendency is, however, to have them made longer than necessary, more especially where a highly bituminous coal is used, 30 to 35 feet long by 7 feet diameter being dimensions very commonly used; and a boiler of this size, after being at work for a few months, will, upon inspection, be found in most cases strongly coated in the seating flues with soot, more especially towards the exit end of the flues; and this, I believe, is caused in a great measure by the excessive distance which the heated gases have to travel before their exit to the chimney, showing very clearly that the temperature at these points, although considerable, was too low to support combustion, and that little good was obtained from this part of the boiler. Following up this idea the writer has for many years past adopted a standard length of 20 to 24 feet for single or double tube boilers, and has found them equal to the longer boiler in efficiency; thus enabling the purchaser to have three boilers for little more than the price of two of the longer type.

In setting boilers too much care cannot be exercised as to the form and position or direction of the flues; and where the boiler is of moderate length it is found advantageous to have the flues returned underneath the boiler to the front end, and back over along the sides to the chimney. Should the boiler be of considerable length, however, this plan is not so much to be commended, owing to the distress caused by arching to the boiler. In this case the flues ought to return along the sides first and afterwards along the bottom to the chimney; and also means adopted for supporting or carrying the boiler. As an instance, many people still follow the injudicious practice of building boilers in with a large mass of brickwork, and thus invite external corrosion to a serious extent, because it (the brickwork) has the effect of keeping any water that may

find its way to the boiler in contact with the plates, and also prevents the detection of any waste that may be going on; and where this state of things is allowed to continue, a rapid oxidation is certain to take place, which ends in the destruction of the boiler in many cases before the owner is aware of the fact. (See Figs. 3 and 4, Plate XII.)

The worst cases of this kind are where internally fired boilers are placed upon very broad side walls, or in some cases a broad middle wall is used of about 18 inches in thickness, and in such cases it is impossible for any inspector to tell by ordinary examination in going along the flues the condition of the plates resting on the brickwork. It frequently happens that to all appearance the plates are in good order until the brickwork is removed, when they are often found considerably decayed and nearly eaten through. The proper remedy for this is to keep the side walls as narrow as possible, consistent with the stability of the boiler, the total breadth being from 3 to 4 inches, but not more, with a loose brick at each ring seam, to facilitate examination.

In all cases where the flues are damp it is advisable to break the contact between the boiler and the brickwork by the use of cast-iron plates, which may be made very narrow, and carried the whole length of the boiler. The arrangement of the brickwork at the front end of internally fired boilers is also a frequent source of trouble by being built up too wide and encircling the sludge pipe; and should there be any leakage here, a thing which is often found, the brickwork absorbs and holds the moisture, causing a rapid corrosion to set in to the ultimate destruction of pipe and boiler bottom in a very short space of time.

Cooling ashes, or permitting them to lie in contact with the plates in front of the boiler, is another source of frequent and considerable damage. This practice ought never to be allowed, but all refuse from ashpit, etc., should be removed as quickly as possible out of the way.

The Plain Cylinder Boiler.

The plain cylinder boiler, although inferior to the Cornish or Lancashire boiler as a steam generator, has much to recommend it on account of its simplicity, less first cost, and economy in repairs, to say nothing of greater freedom from explosions. Moderate lengths, say not exceeding 30 feet, ought to be observed to prevent distress from arching, which in any case takes place to a greater or less degree, according to circumstances; and it has come under the writer's notice repeatedly that boilers of great length have been rent asunder on the underside from this cause alone. The old method of setting these boilers with wheel flues has fallen into disuse, the flash flue being generally adopted with various modifications—such, for instance, as throwing cast iron girders transversely over the boiler to receive the suspension bolts for carrying the boiler, the said bolts being attached to the boiler by a strong T bar or a couple of angle irons riveted on, three girders, having three bolts each, being generally used, and in some cases volute springs have been applied under the nuts of the suspension bolts to equalize the weight. Either of the above methods of carrying a boiler have an advantage over the old-fashioned knee or saddle, inasmuch as they enable the weight to be distributed over the various points of suspension after the boiler has got to work, and this is a matter of great importance for relieving the strain upon the middle, caused by the ends coming up under the expansion of the bottom plates. In numerous cases, too, the brickwork is closed in at or below the centre of the boiler, with a view no doubt to prevent the possibility of the heat or flame reaching the plates above the water level;

this precaution has been proved by long experience to be quite unnecessary, and is a great hindrance to the generation of steam, by exposing such a large area of plate to the atmosphere for radiation of heat, instead of having it added to the flue for generating steam, two fire bridges being commonly used—one immediately behind the fire, the other at the termination of the cylindrical part of the boiler at the chimney end—such bridges being invariably about 12 inches or more from the boiler bottom, and the intervening distance between them from 3 to 4 feet down below the top of the bridges, and consequently offering a large area of escape for the heat without coming into contact in any way with the plates. These and other similar mistakes have contributed in no small degree to place the boiler in an unfavourable position in the opinion of the steam user as being as extravagant in fuel. It has been found in practice, however, that when this boiler is properly seated and attended to, it is capable of giving very satisfactory results, and recent improvements have gone far to render it only slightly inferior to the more expensive kinds; and in many instances where Young's furnace and arrangement of bridges and flues have been adopted, a net saving of 30 to 40 per cent. in fuel, and 50 per cent. in labour has been effected. The principal features in this arrangement are (see Figs. 1 and 2, Plate XIII.)—1st, the greatly increased area of heating surface which is obtained by the peculiar arrangement of this flue, which enables the brickwork to radiate or throw back the heat upon the plates, which causes the boiler to act with increased efficiency; 2nd, the increased number and position of the bridges. By this means the large area of opening over the fire bridge is reduced to the least possible limit, and so with all the other bridges, the consequence being that a large volume of heat is prevented from passing away to the chimney without doing any useful work; because, however large the opening over the bridges may be, it is clear that the upper surface only of the heat and volume will be in contact with the boiler; so that any excess of opening over and above that which is just necessary for ensuring a good draught is a direct source of waste and extravagance in fuel. In conjunction with this arrangement it has been found by experience that little more than one-half the usual grate area is necessary in most cases for obtaining the same amount of work from a boiler, hence the large saving in both fuel and labour.

The method of firing or serving these furnaces with fuel is considered to have decided advantages over the usual doors, a couple of teeze holes being used instead, similar to the puddling or forge furnace. Duff coal being extensively used, it is piled up in front to allow the volatile ingredients to be distilled, and get partly coked before being pushed forward into the fire, which to some extent prevents smoke and also the duff from being carried over the bridge into the flue. And last, though by no means least, the cold air is prevented from rushing in upon the heated plates, thus causing these troublesome lap-edge fractures so frequently met with and so much dreaded by those in charge of boilers.

In concluding this third part of the subject, the writer feels the great difficulty which attends the task he has undertaken. The mass of materials so willingly and generously placed at his disposal has rendered it far from easy to make a judicious selection of facts, figures, or theories, and he craves the indulgence of his readers for many imperfections and omissions. In the fourth and concluding part it is intended to deal briefly

with boilers *per se*, and also to abstract the scope of the paper; on the entirety of which the writer trusts to evoke a discussion which will, far more than his own feeble efforts, eventually lead to increased safety without disregarding the kindred necessity—economy.

Mr. BUNNING said, that any machinery which utilized 47 per cent. of heat units of the coal must have been very perfect and far in excess of what had usually been considered possible. Mr. Emerson Bainbridge, in a paper read before the British Association in Sheffield, had shown that a very much lower percentage than this was considered a very excellent result.

Mr. D. P. MORISON said, that the 47 per cent. was the amount of useful effect of the coal which might be available for the engine. Probably the total amount utilized altogether by the engine and boiler together did not amount to 15 per cent.

Mr. W. COCHRANE was surprised at the small result of 5 lbs. of water per 1 lb. of coal obtained from Root's boiler; he had obtained as much as 10 lbs.; the class of coal used in the experiments would of course affect the result.

Mr. S. B. COXON asked if much difference had been observed between the results obtained from best screened and small coal?

Mr. D. P. MORISON replied that there was no doubt best screened coal gave better results than small coal, but that nuts had been found to be better than either. He noticed that in one experiment with a Root's boiler 7·3 lbs. of water to 1 lb. of coal had been obtained with screened South Durham coal. The results of the experiments given in his paper must be understood to be a rough average.

Mr. S. B. COXON asked Mr. Morison if in testing boilers he preferred doing so with the manhole door off, allowing the steam to escape at the pressure of the atmosphere, or whether he thought it better to do so under pressure, and if the latter, whether the result might not be very much interfered with from the primings which would probably take place?

Mr. MORISON replied that he personally would prefer testing the boilers under the pressure they were constructed to carry in their every day work.

Mr. T. W. BUNNING stated that the Government experiments were always made at the pressure of the atmosphere, and the records always modified to one uniform temperature of feed of 100 degrees Fahr., notwithstanding the actual temperature of the feed-water used. Theoretically, also, it made no difference under what pressure these experiments were made, as for the purposes of examination amongst themselves they could be

always modified to any given standard required. Practically, however, there was less danger of the results being vitiated by priming when they were made simply under atmospheric pressure.

Mr. J. A. G. Ross said, that from his experience it was usual to make the experiments under pressure, and thought that the results would be more satisfactory as being obtained in the normal state of the boiler when at work, and these results he considered would differ very considerably from those attained simply under atmospheric pressure as the temperature of the water itself would be very much greater, as also would be the loss of heat by radiation.

The CHAIRMAN said, that there were well-known formulæ for reducing experiments taken from any temperature of feed under any pressure to one given standard.

Mr. MORISON said, that he was sorry to differ from Mr. Bunning, who had had a very great experience in testing coals; but he quite agreed with Mr. Ross in considering that it was preferable to test the performance of boilers while under their working pressure.

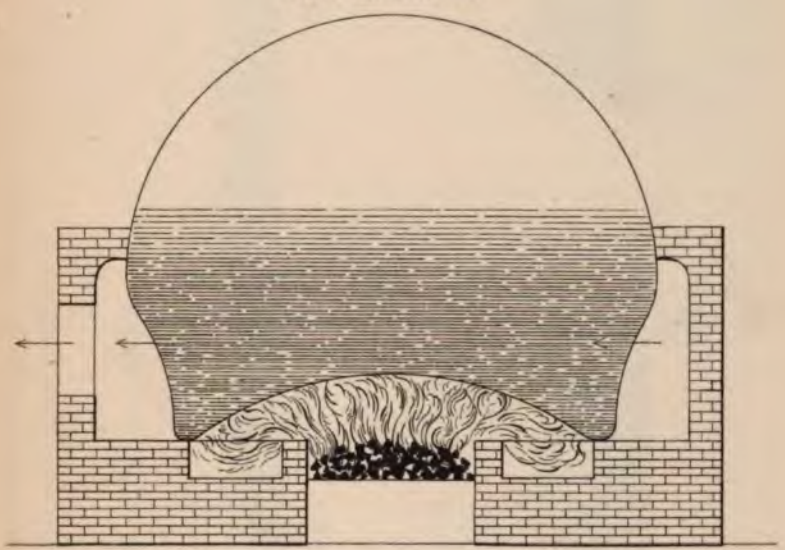
Mr. COOKE then proposed a vote of thanks to Mr. Morison for his valuable paper.

Mr. COCHRANE seconded the motion, which was unanimously carried, adding that the collection of such a mass of useful information must have given Mr. Morison a large amount of trouble, and that the Institute was much indebted to him for the valuable addition he had made to their Transactions.

The meeting then separated.

To illustrate Mr D.P. Morison's paper "On Boiler Accidents and their prevention."

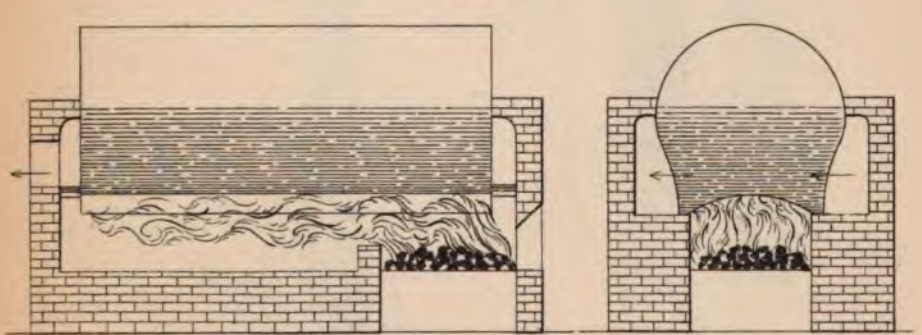
FIG. 1. BALLOON



SECTION

Scale 8 feet - 1 inch

FIG. 2. WAGON



ELEVATIONAL SECTION

CROSS SECTION

To illustrate Mr. D. P. Morison's paper "On Boiler Accidents and their prevention."

FIG. 1 _ LONG PLAIN CYLINDER

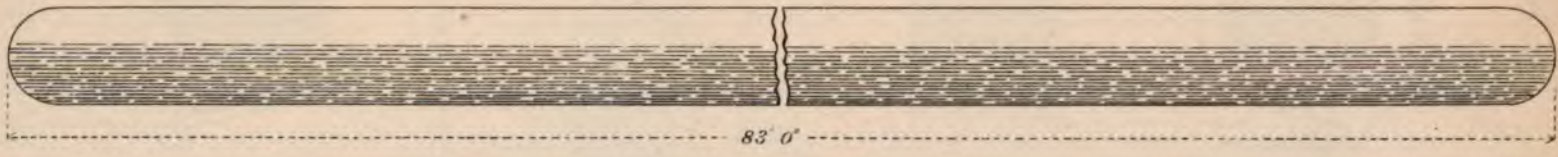
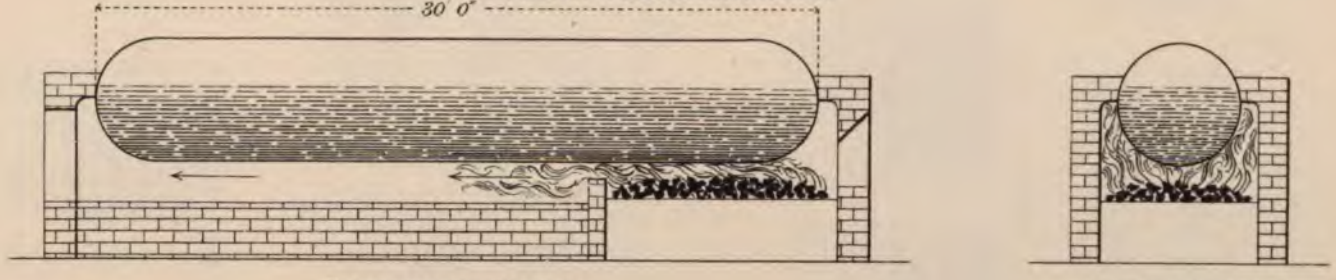


FIG. 2 _ PLAIN CYLINDER



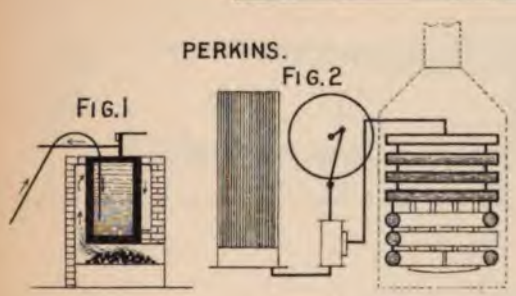
ELEVATIONAL SECTION

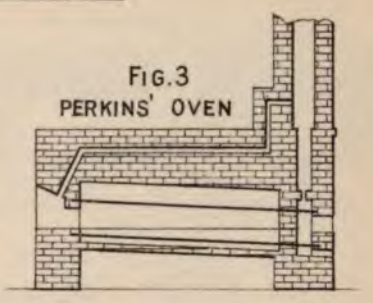
CROSS SECTION

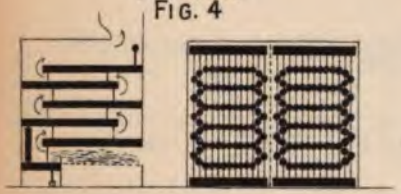
Scale 8 feet = 1 inch

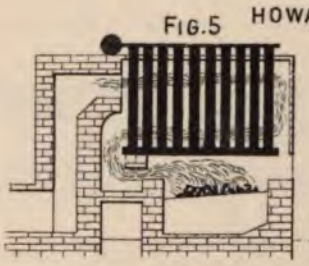
Andw. Reid, Newcastle.

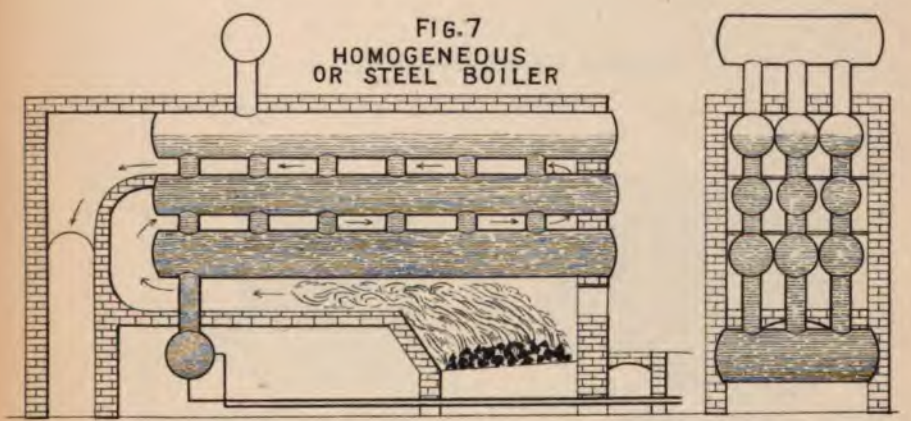
To illustrate Mr. D. P. Morison's paper "On Boiler Accidents and their prevention."











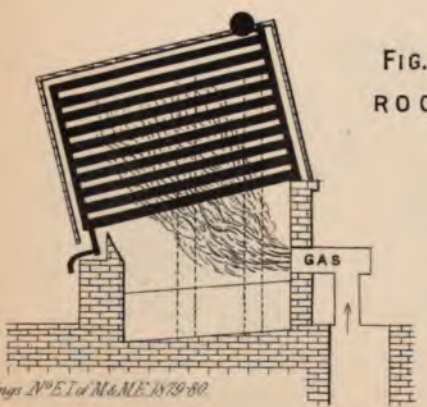
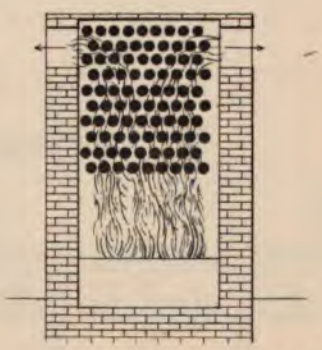


FIG.8
ROOT



And. Reid Newcastle

To illustrate Mr D.P. Morison's paper "On Boiler Accidents and their prevention".

FIG. 1 _ CORNISH

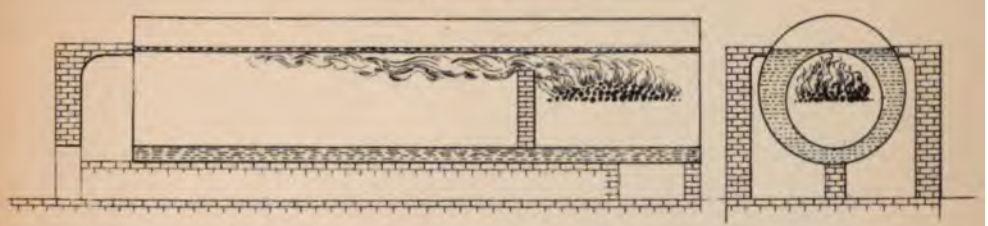


FIG. 2 _ LANCASHIRE

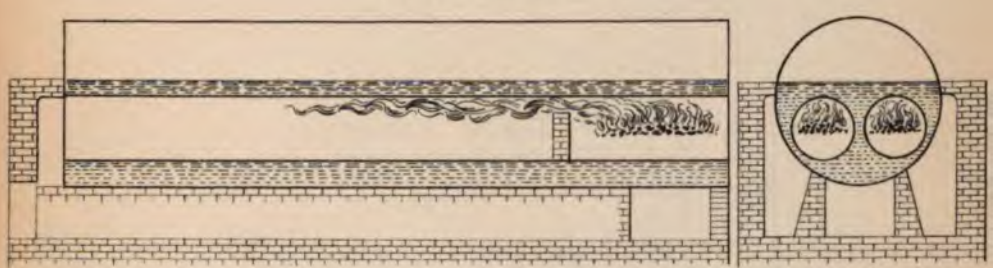


FIG. 3 _ CIRCULAR MARINE

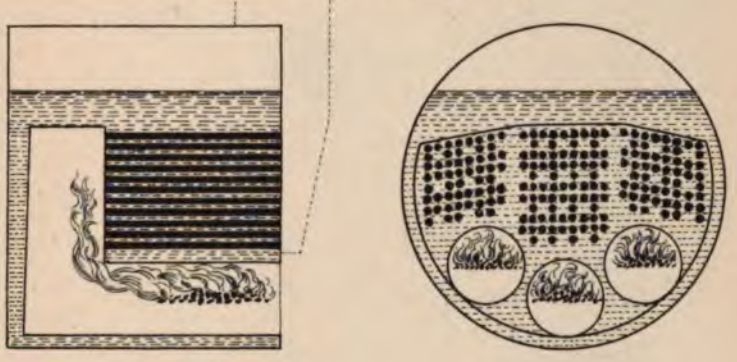
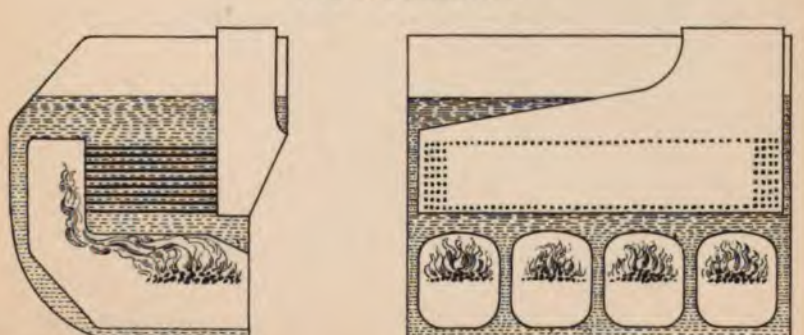
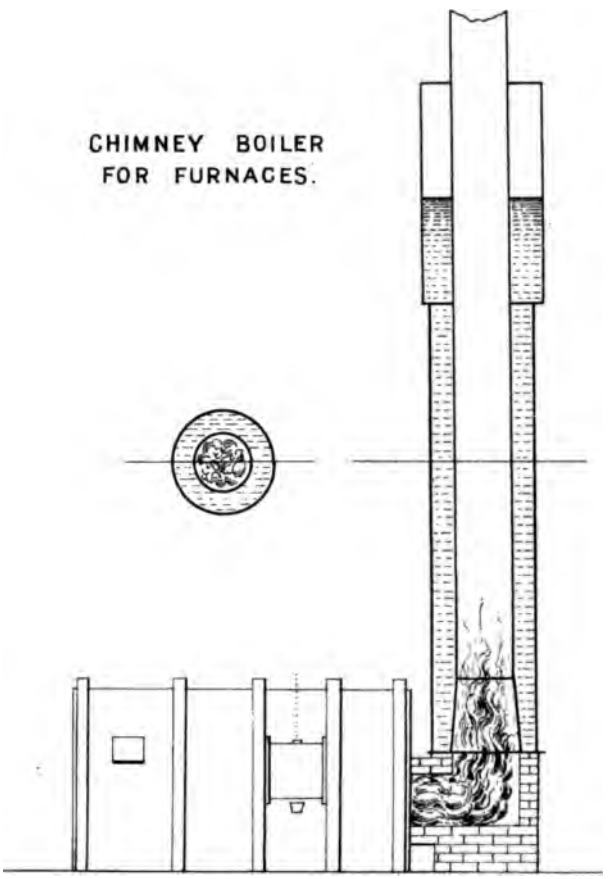


FIG. 4 _ MARINE

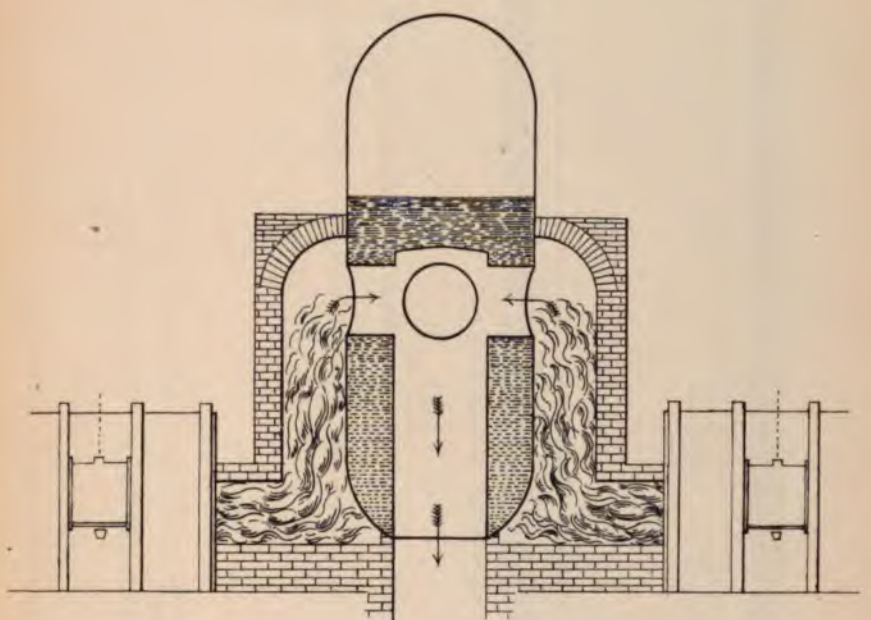


To illustrate Mr. D.P. Morison's paper "On Boiler Accidents and their prevention."

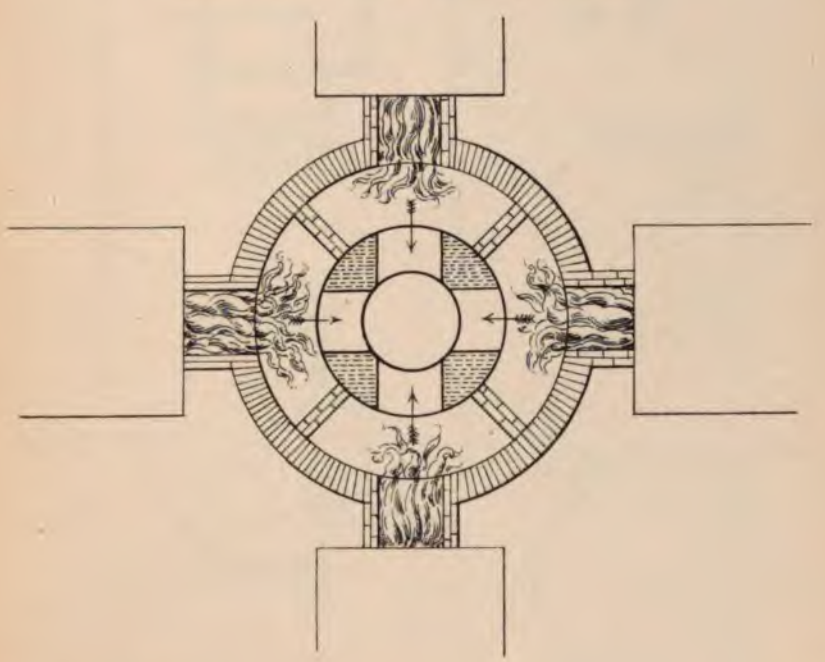


Andt Rend. Newcastle.

To illustrate Mr. D.P. Morison's paper "On Boiler Accidents and their prevention".



RASTRICK BOILER FOR FURNACES.



Andr. Reid, Newcastle.

To illustrate Mr. D. P. Morison's paper "On Boiler Accidents and their prevention".

LANCASHIRE BOILER SEATINGS_(HAWKSLEY, WILD & Co's DESIGN)

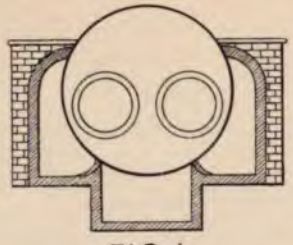


FIG. 1.

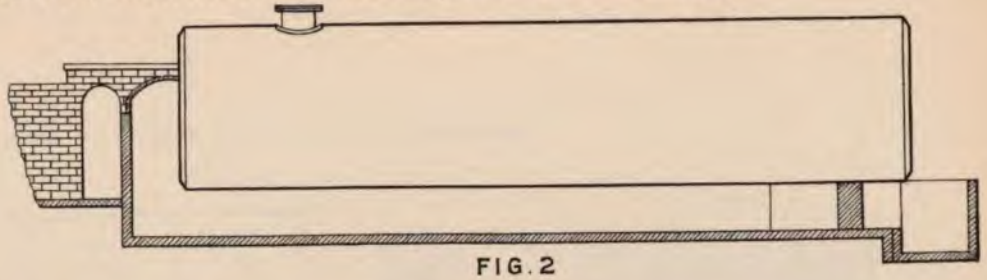


FIG. 2

BOILER SEATINGS_(YOUNG'S DESIGNS)

FIG. 3.
(EASY OF ACCESS)

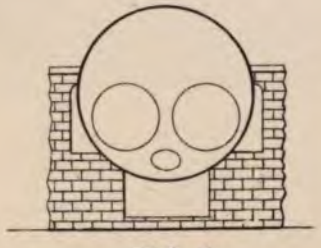


FIG. 4.
(DIFFICULT OF ACCESS)

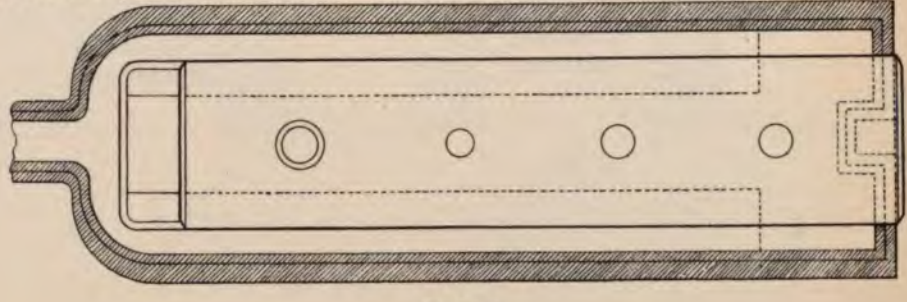
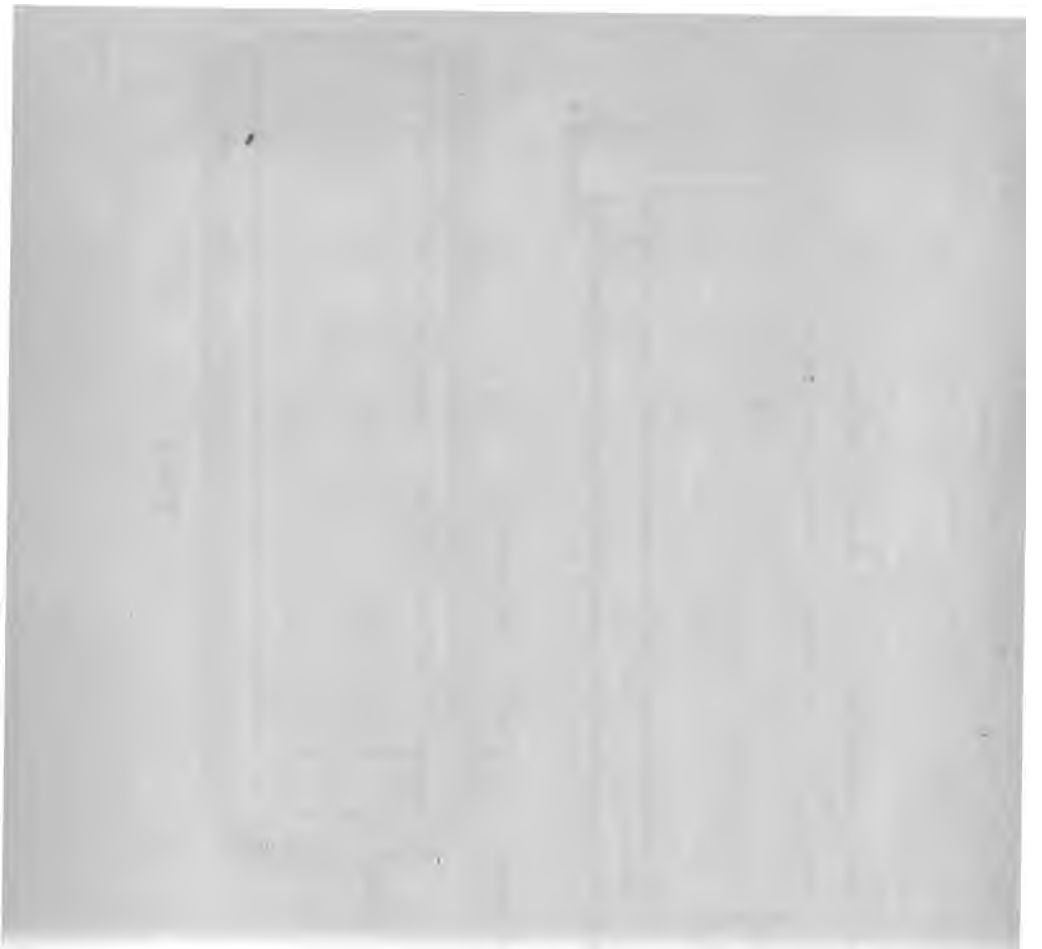


FIG. 5

Proceedings No. E.I. of M.&M.E. 1879-80

Andr. Reid, Newcastle.



To illustrate Mr. D. P. Morison's paper "On Boiler Accidents and their prevention".

YOUNG'S FURNACE FOR PLAIN CYLINDERS

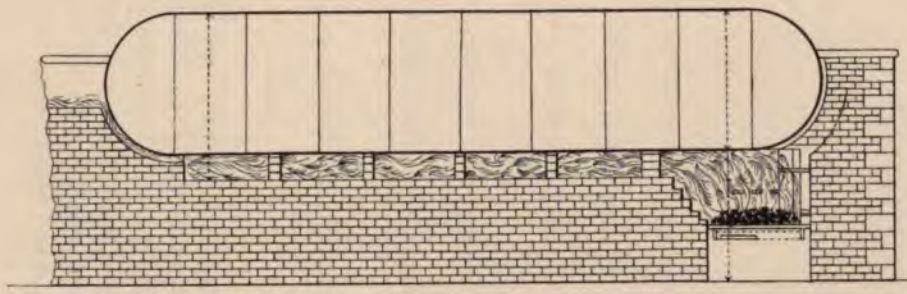


FIG. 1.

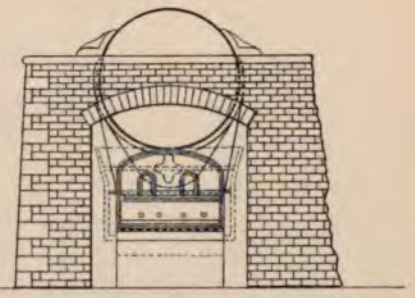


FIG. 2

Jas. Reid, Newcastle.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, FEBRUARY 7TH, 1880, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

G. C. GREENWELL, ESQ., IN THE CHAIR.

THE SECRETARY read the minutes of the last General Meeting and the minutes of the Council meetings.

The following gentlemen were elected :—

ORDINARY MEMBERS—

Mr. EDWARD GAWLER PRIOR, Government Inspector of Mines, Nanaims, British Columbia.

Mr. WILLIAM FREDERIC BUTLER, Civil Engineer, 6, Queen Anne's Gate, Westminster, S.W.

Mr. WILLIAM ACKROYD, JUN., Morley Main Collieries, Morley, near Leeds.

STUDENT—

Mr. R. CECIL PEAKE, Harton Colliery Offices, South Shields.

The following was nominated for election at the next meeting :—

STUDENT—

Mr. CHARLES JAMES MURTON, Jesmond Villas, Newcastle-on-Tyne.

The PRESIDENT remarked, that the minutes of the Council meeting held that day, read by the Secretary, stated that the President had brought forward the subject of the appointment of a mining lecturer to the Institute. He had brought forward the question in consequence of a letter which he had received from the North Staffordshire Institute of Mining and Mechanical Engineers, which stated that it had long been the object

of those interested in that Institute to extend its usefulness by promoting the more general study of those sciences pertaining to mining and engineering; and with this view they had arranged for classes which they believed would be of great service to the members. The subjects would be practical chemistry, geology, and mining engineering. The practical mining classes would include the study of gases and other chemical phenomena found in mines, and also analyses of the different minerals connected with mining which are of such importance in the present scientific state of the iron and steel industries. It appeared to him that there are two classes of persons connected, or about to be connected, with collieries; for one, the young, all the scientific instruction necessary is already provided in the classes now so well conducted in the college and schools of this neighbourhood; but as to the other, namely, those persons actually and practically employed in the work of collieries—he meant overmen and others who had not either the means or the time to avail themselves of the privileges offered in the earlier stage of life—evening instruction, such as that contemplated by the North Staffordshire engineers, would be more valuable. He understood that it was already in contemplation to appoint a chair for instruction in mining—such chair would give very much such instruction as regards mining as is given to the present classes in chemistry; but it would not be to any large extent of that description which would be desirable for the class of people of whom he had spoken. He therefore thought that if a mining professor should be appointed, periodical lectures should be given, and it would be desirable, if possible, that the professor should be a practical as well as a scientific man. It was a subject of general remark, and he had regretted it very much, that there were frequently men well able from their practical knowledge to become managers of collieries, but who in the examination which it is necessary they should pass in order to obtain their certificates, fail for want of the knowledge which might be imparted by such classes as he had spoken about.

Mr. J. B. Simpson said, it was the intention of the College of Physical Science to appoint a mining professor. The question was to be considered by the Council in the ensuing week, and probably it would be better to allow the question to remain open until it was seen what was done by them. The object to be obtained was the same as that which was originally intended when the college was commenced, and which had always been kept before the Mining Institute; and he thought that the education which would be given by the college through the professor of mining would carry out what Mr. Greenwell's intention seemed to be, that

was, to give a theoretical knowledge of mining to those who had not had the benefit of education; and, although that would not probably apply to most of the students who attended in the day time, yet in the evenings, no doubt, the professor of mining would be able to have classes which could be attended by overmen and others from the collieries round about. If a little time were given, the members would see whether the course which the Physical Science College was about to take would meet Mr. Greenwell's views on the subject.

The subject then dropped.

At the suggestion of Mr. JOHN H. MERIVALE, and on the recommendation of the Council, the Secretary was instructed to write to the Registrar-General and ask him to add the profession of "Mining Engineers" to those already given in the results of the census of 1871, showing the occupation and ages of people at death.

Mr. T. J. BEWICK then read the following Memoir of Mr. Thomas Sopwith :—

MEMOIR OF MR. THOMAS SOPWITH.

By THOS. J. BEWICK.

Thomas Sopwith, M.A., F.R.S., was born in Newcastle-upon-Tyne, on the 3rd of January, 1803, and received his education at private schools in that town and in Gateshead.

He was first apprenticed to his father, who carried on with success a large cabinet-making and joinery business in Newcastle, and although retaining an interest therein for many years, he did not long continue to practically follow it. He had much taste for drawing, and became a rapid and correct sketcher, in which he excelled all his life. He likewise devoted himself much to scientific and literary pursuits. He rose early; was active, industrious, and persevering; and thus it was, whilst still at the bench from early morn to late at night, he found time to study architecture and the use of optical and philosophical instruments, in which he became proficient. Thus in 1822, when only nineteen years of age, he designed a new gaol for his native town, and illustrated it by models and plans, which secured for him the commendation of the authorities, and a gratuity of ten guineas was voted to him.

On attaining manhood he, with his father's consent, left the business, to study land and mining surveying at Alston Moor, and in this he soon made himself so competent that Mr. Dickinson, under whom he had studied, took him into partnership.

Having made mine surveying and engineering a special study, he quickly became noted for the correctness of his surveys, and the neatness and detail of the plans and sections which he prepared therefrom.

During the four years he remained at Alston he, in conjunction with his partner, prepared detailed plans and sections of the lead mines in Alston Moor, belonging to the Commissioners of Greenwich Hospital. He was also during this period engaged in making surveys and plans for

the Corporation of Newcastle and others. These occupations did not, however, prevent him following the bent of his mind, for in 1826 he published his first book, being an account and plans of the interior of All Saints' Church, in Newcastle-on-Tyne, and made sketches of various public buildings and private works, the latter principally those of a mining character.

It was during this time that some etched plans and sections of the great Hudgill Burn Lead Mine, which he had prepared, came to the knowledge of Dr. Buckland, the celebrated professor of geology, and led to an intimacy ending only in the doctor's death.

While at Alston he made the acquaintance of the late Mr. Hugh Lee Pattinson, so well known as the inventor of the de-silverizing process bearing his name, and a close friendship continued until the death of Mr. Pattinson.

Having established himself as a civil and mining engineer in Newcastle, he soon found much occupation in the profession he had adopted. In 1830 he surveyed and levelled a new road between Newcastle and Otterburn, and was consulted by many of the county gentry on various matters affecting their estates.

In 1832 he entered upon new offices in the Royal Arcade, which he continued to occupy until 1845, when he received the appointment of chief agent of the W. B. Lead Mines in Northumberland and Durham.

In these thirteen years he was occupied professionally on many local undertakings, such as the new streets and improvements of Newcastle, carried out by Mr. Richard Grainger; the coal and iron mines of the Forest of Dean, of which he made detailed surveys, and prepared sections, and a model of the entire Forest, showing the beds of coal and workings therein, and reported thereon to the Woods and Forests Department of the Government; the Newcastle and Carlisle, the Great North of England, the Newcastle and Berwick, the London and Brighton, and other railways in England, as well as the Sambre and Meuse Railway in Belgium; a road from Newcastle to Shotley Bridge, and an extension to Middleton-in-Teesdale; works connected with the improvement of the River Tyne; and many others of a similar but less extensive character. Whilst occupied on these undertakings he made the acquaintance of many eminent men, professional and otherwise. Amongst others may be named the late Messrs. George and Robert Stephenson, Mr. John Buddle, Mr. Nicholas Wood, Mr. Richard Grainger, Sir William Cubitt, Mr. I. K. Brunel, Mr. J. M. Rendel, and Mr. Bryan Donkin.

After 1845, although not taking an active part publicly in the pro-

fession, he yet, in conjunction with the late Mr. Marcus Scott, his brother-in-law, and Mr. T. Macdougall Smith, carried on an extensive practice as civil and mining engineers in London.

Having previously been engaged in connection with the mines of the Forest of Dean, he was, under the Act 1 and 2 Vict., c. 43, for regulating the opening and working of mines and quarries in the Forest of Dean, in the County of Gloucester, which received the Royal assent on 27th July, 1838, appointed by the Government Commissioner on behalf of the Crown, his colleagues being John Probyn, Esq., of Gloucester, selected by the Free Miners, and John Buddle, Esq., the eminent colliery viewer, who was the third Commissioner or Umpire.

The inquiry extended over three years, and in July, 1841, the Commissioners made their award, which, by order of Her Majesty's Commissioners of Woods, Forests, and Land Revenue, was in the same year published, and the task of preparing the award and accompanying map for publication devolved on Mr. Sopwith.

On frequent subsequent occasions Mr. Sopwith acted professionally for the Government in connection with Crown properties.

From 1845 to 1871, a period of twenty-six years, Mr. Sopwith was chief agent of the W. B. Lead Mines, belonging to the Beaumont family, the representative of which is, and was during the greater part of Mr. Sopwith's connection therewith, Wentworth Blackett Beaumont, Esq., M.P. The first twelve years of this period Mr. Sopwith resided almost constantly at Allenheads, and here, in the midst of the workmen and their families, he was ever busy in promoting the interests of his employer, but in so doing did not forget the well-being of those acting under him, whether as agents or workmen. He took great interest in the comfort of those around him, and in the education of the children whose parents were dependent on the industry over which he presided. In these matters he found in Mr. Beaumont a zealous and liberal chief. The houses were improved, and many new ones built, with due regard to the health and comfort of the inmates. Several schools were erected in the various districts comprised within the limits of the vast property of which Mr. Sopwith had charge. These schools were open to all denominations alike, and the mode of teaching religious lessons, as carried out at these schools, was shown by Mr. Sopwith in evidence given by him before a Parliamentary Committee, when he illustrated the various lessons a teacher might give from the 19th Psalm. The children were made to think, and every writing lesson was a useful piece of information; punctuality was constantly enforced, and a system, which Mr. Sopwith

called "drill arithmetic," was successfully carried out. Object lessons, freehand and geometrical drawing, grammar, composition, geography, and, not least, the importance of punctuality, integrity, and good conduct in every relation of life, were seduously enjoined and constantly illustrated and enforced.

In addition to the schools, miners' rooms were erected, libraries and news rooms established, and benefit societies formed at the different centres on a larger scale than had previously been attempted, all of which tended greatly to the comfort and improvement of the workmen and others.

After 1857 Mr. Sopwith lived in London, but still acted as Mr. Beaumont's chief mining agent. Although less frequently present amongst the workmen, he continued up to his retirement in 1871 to take the same lively interest in the well-being of the people, and devoted much time to their social welfare.

In June, 1871, after holding the appointment twenty-six years, Mr. Sopwith resigned his office of chief agent at the W. B. Lead Mines, and retired from the active duties of the profession, having been engaged in it just half a century.

On his retirement he was entertained at a complimentary dinner, and presented by the agents and workmen of the W. B. Lead Mines and others with a handsome service of plate, "as a testimonial of their respect and esteem of his skill and integrity in the discharge of his duties during a period of twenty-six years; and also to mark their appreciation of his zealous efforts in promoting education and other benevolent objects." At the same time he was presented with a lengthy address from the workmen, testifying to the great interest he had ever evinced towards them and their families, and expressing in warm terms their gratitude and thankfulness, and their regret that his retirement from the active duties of his profession was the end of a beneficial supervision, and the breaking of the close link which had existed between them for over a quarter of a century.

Mr. Sopwith was the author of several books and papers. Amongst them may be mentioned "A Historical and Descriptive Account of All Saints' Church in Newcastle-upon-Tyne," published in February, 1826, when Mr. Sopwith had only just completed his twenty-third year; "An Account of the Mining Districts of Alston Moor, Weardale, and Teesdale," published at Alnwick in 1833; and in the following year was issued his largest work on "Isometrical Drawing," which went through several editions. Besides these Mr. Sopwith was the author of some books on travel, educational and other subjects, and not unfrequently contributed articles to magazines and newspapers.

On the occasion of the British Association meeting in Newcastle-on-Tyne in 1838, Mr. Sopwith took an active part in promoting its success, and contributed six papers on various subjects, one of which was "Suggestions on the Practicability and Importance of Preserving National Mining Records," which led to the appointment of a Committee of the Association, consisting of the Marquis of Northampton, Sir Charles Lemon, Bart., Mr. Buddle, and Mr. Sopwith, which succeeded in inducing the Government to take up the subject, and resulted in the establishment of the present department for Mining Records at the Museum of Practical Geology, in Jermyn Street, London.

When the British Association assembled in Newcastle for the second time, in 1863, Mr. Sopwith was again active in securing its success. He was one of the secretaries of the Geological Section; contributed a paper on "A Section of the Strata from Hownes Gill to Cross Fell;" and, in conjunction with the late Mr. Thomas Richardson, prepared the report "On the Local Manufacture of Lead, Copper, Zinc, Antimony, &c." On this occasion one of the excursions of the members of the Association was to Allenheads, when in spite of a pouring rain a day of great interest and enjoyment was experienced, in which Mr. Sopwith took a prominent part.

In May, 1833, Mr. Sopwith was elected a member of the Institution of Civil Engineers, and at his death there were only twelve members on the list who had been elected at an earlier date. In the proceedings he took much interest, was a member of the Council in 1846, 1847, and 1848, and occasionally took part in the discussions at the weekly meetings of the Institution, the last occasion on which he addressed the members being within a few weeks of his death.

On the 5th June, 1845, he was elected a Fellow of the Royal Society, and in 1857 had conferred upon him the honorary degree of M.A. by the Senate of the University of Durham. He was also from 1845 a Fellow of the Society of Arts, and from 1858 to 1863 was on the Council; a Fellow of the Geological Society and other kindred institutions, and to all, or nearly all, the societies with which he was connected he contributed papers. He took a warm interest in local institutions, and actively promoted lectures to the working classes, and exhibitions of works of art and industry in his native town.

Of our own Institute he became a member in 1853 and continued until 1877, when, living as he then was far from the scenes of our labours, he retired, leaving his only sons (Mr. Thomas Sopwith and Mr. Arthur Sopwith) on the list of membership. He contributed in 1865 a paper on "The Lead Mining Districts of the North of England."

Amongst Mr. Sopwith's intimate friends, are to be numbered Professors Buckland, Sedgwick, Conybeare, John Philips, Faraday, and Pillans, George and Robert Stephenson, Robert and William Chambers, Sir Roderick Murchison, Sir Francis Chantrey, Charles Babbage, John Buddle, Sir William Cubitt, and Mary Somerville the authoress, with each of whom he carried on friendly and scientific correspondence.

He had considerable mechanical and geological knowledge, and in the latter more particularly was frequently consulted on important matters, whilst in the former he was the inventor of the Telescopic Levelling Stave and the Monoclied Cabinet, an ingenious and admirable arrangement of writing desk and drawers combined under one key. He likewise designed the series of geological models, now so well known by students and others, constructed of different coloured woods as representing various beds of rock, and showing with extreme clearness the effect resulting from dislocations, denudation, etc. An excellent model of the Forest of Dean, showing the surface and the more important beds of coal, was prepared from the designs and under the direction of Mr. Sopwith for the Commissioners of Woods and Forests, and is now placed in the Museum of Practical Geology in London. Somewhat similar models were constructed by Mr. Sopwith of the Ebbw Vale and Sirhowy Iron Company's property and mines of coal and iron in Monmouthshire, and of lead and other mines in different parts of the country.

The well-known hydraulic machinery for pumping, winding, crushing, and other purposes at the W. B. Lead Mines was designed and erected by Sir W. G. Armstrong, acting under Mr. Sopwith's instructions.

Mr. Sopwith entered on his career when the engineering profession was, it may be said, in its infancy. The Stockton and Darlington Railway was opened when he was twenty-two, and the Liverpool and Manchester line before he had attained his twenty-seventh year. It was not however railways to which he especially devoted his attention: from the first he appears to have laid out a course for himself which eventually placed him in the front rank of metalliferous mining engineers. Great industry, exactness in details, clearness of expression, methodical to a fault, and conscientious in all his transactions, were characteristic of Mr. Sopwith. He was a fluent speaker and a ready and precise writer, as is proved by his journals, which consist of 168 volumes, containing interesting descriptions of places and people, interspersed with numerous and amusing pen-and-ink sketches which would do credit to a professional artist. This journal was begun when he was eighteen years of age, and continued to within a fortnight of his death, a period of fifty-eight years, with the same characteristic neatness and exactness.

Up to within a few months of his death, which occurred at his residence in London, on the 16th of January, 1879, at the age of 76, Mr. Sopwith enjoyed excellent health. He was fond of travelling, and visited many places on the Continent; and few localities of interest in the British isles were unknown to him. With his natural flow of high spirits, conversational powers, and well-stored and retentive memory, he was a genial companion and a good friend, and will long be remembered with feelings of satisfaction by those whose advantage it was to have the pleasure of his acquaintance.

The writer's connection with Mr. Sopwith dates from January, 1836; he served his articles of apprenticeship with him, and continued as his assistant until 1846, from which time until 1866 he acted under him as engineer of the W. B. Lead Mines, and subsequently a more or less close professional and friendly intercourse continued to exist up to Mr. Sopwith's decease.

Much of the preceding is within the writer's personal knowledge, but he has in addition been greatly indebted to a memoir of Mr. Sopwith, published in the Transactions of the Institution of Civil Engineers, recently issued, and from which, with the permission of the writer, he has freely copied, and for which he heartily offers his acknowledgments.

Mr. STEAVENSON thought that the meeting would agree with him that their time had been well spent in listening to the record of a useful life such as had just been so attractively described by Mr. Bewick, and he had great pleasure in moving a vote of thanks to that gentleman.

Mr. COOKE seconded the motion, which was unanimously carried.

The following papers were then read:—"Notes on the Mueseler Lamp," by Mr. A. R. SAWYER, and "Improved Safety-lamps on the Davy and Mueseler Types," by Mr. JAMES ASHWORTH.

As these papers contain many allusions to the Mueseler lamp, it has been thought advisable to print a translation of a report of a committee

nominated in Belgium by Ministerial decree the 20th January, 1867, the powers of which were enlarged by another decree dated 20th January, 1868, which was published in the year 1873, and also a translation of the royal decree concerning safety-lamps bearing date 17th June, 1876, which have obligingly been placed at the disposition of the Institute by Mr. C. G. Jackson, of Wigan.

SAFETY-LAMPS FOR MINES.

Report of the Commission instituted in Belgium by Ministerial Decree dated the 20th of January, 1868.

By a decree dated the 16th of April, 1867, the Minister of Public Works appointed a Commission of Engineers to examine whether it was advisable to allow the use of certain safety-lamps fed with petroleum oil for the lighting of fiery mines.

This Commission had commenced its report, when, in 1868, in consequence of experiments made in England on mining lamps placed in explosive currents moving at a high velocity, the Minister enlarged the scope of the Commission by a decree dated the 20th of January, intrusting it with the examination and comparison of the various lighting apparatus, including those which were already in use in mines as well as those which had been recently proposed, whether fed with vegetable or mineral oil. The members of the Commission were also finally selected at the same time.*

The enlargement of the programme caused the presentation for trial of a very large number of lighting apparatus. A Sub-Commission was named from the Commission itself for the purpose of proceeding with such preliminary experiments as would justify a preparatory elimination. Several events interrupted the labours of the Commission: they were resumed in 1872, and resulted in a numerous series of experiments; these experiments, as well as those undertaken in 1868 by the Sub-Commission, took place at one of the gas-works in Liége.

The circumstances and results of the experiments are recorded in the detailed tables published afterwards, which tables should be considered as having to some extent guided the Commission in their report. To these

* After various changes it was in the end composed of:—MM. Jochams, Inspector General of Mines, President; Trasenster, Professor at the University of Liége, Vice-President; Laguesse and Van Scherpenzeel-Thim, Chief Engineers; Chandelon, Professor at the University of Liége; Lambert, Principal Engineer; E. Mockel, Director of Coal Mines; Harze, Engineer, Secretary; Schorn, Engineer, Assistant Secretary.

tables are added a descriptive table of the lamps, and some sketches; the latter, although not indicating the details of the working of the different parts, are, nevertheless, quite sufficient to show the character of the proposed innovations.

The apparatus used for the experiments, which it is not necessary here to describe in detail, consisted of a box-gallery of wood in which the lamps were placed to be tried; one of the sides was pierced with apertures furnished with thick glasses which allowed all that was going on inside to be seen. A centrifugal fan driven by a steam engine caused a rapid current of air in the box-gallery, into which, at any given moment, the illuminating gas, coming from a gasometer specially reserved for the experiments of the Commission, could be introduced. An hydraulic valve served to introduce, stop, and regulate the emission of the gas. The box-gallery was shut up in a dark chamber in order that the phenomena in all their details might be better observed; the lever by means of which the valve was worked was placed in the interior of this chamber.

The action of the machine could be very easily regulated so as to obtain currents of a very appreciably uniform velocity during the period of a series of experiments. This uniformity was confirmed by numerous observations by means of Biram's and Dickinson's anemometers; the latter particularly being able to be used easily and quickly, was employed at frequent intervals to control the working of the engine.

Concerning the composition of the mixture, special experiments were made to approximately determine the proportions of gas corresponding to different openings of the valve. These experiments gave the following results for a velocity of six metres of the mixture:—

Opening of the Valve.	Proportion of Gas in the mixture.	Explosive effects obtained.
Notch A	11½ per cent.	Simple inflammation.
" B	14 "	Explosion.
" C	16 "	Violent explosion.
" C′	18½ "	
" D	24 "	The mixture ceased to burn.

The experiments were generally made with mixtures moving at a velocity of about 19·68 feet per second, a velocity known to be dangerous for the ordinary Mueseler lamp, whilst a velocity of from 9·84 to 13·12 feet has in almost every case been found safe.

In order to study in as complete a manner as possible all the phenomena which these lighting apparatus may exhibit under all the different circumstances attendant on their habitual use, and to report with some certainty upon the degree of confidence that can be attached to the different systems of apparatus, the Commission introduced into the experiments certain exceptional tests and conditions, viz.:—

Firstly—Continuing the experiment as long as possible, that is to say, during five or six minutes; the quantity of gas enclosed in the gasometer would not permit of this time being exceeded when the speed of the current was about 19·68 feet. When the Mueseler lamp was placed in an explosive current of this velocity, it was remarked that after the extinction of the wick the gas continued to burn under the horizontal gauze; and it was feared that this combustion prolonged for a certain time would cause the horizontal gauze to become red hot, and by that means pass the flame to the outside; nevertheless, few explosions were produced by experiments of this kind, and it may be said that the excessive prolongation of the action of rapidly explosive mixtures upon the Mueseler lamp is not, by itself, a positive cause of explosion.

Secondly—Covering the horizontal gauze of the lamps with oil and sprinkling it over with fine coal dust, to imitate the condition of a lamp which has been upset and either has not been extinguished by the fall, or when extinguished has been relit by a careless person. It was ascertained that the lamps, when in this state, pretty easily produced explosions, especially when the explosive current was moving at a high speed.

Thirdly—By subjecting the lamps experimented on to motion, as the lamps of workmen, when moving about in the workings of the mine, are often subjected to more or less rough and violent oscillations, according to the degree of precaution of the persons who carry them. Some experiments tried on this effect have made it obvious that the safety of the lamp is diminished by moving it to and fro, particularly in the case where a lamp which oscillates is suddenly surrounded by an explosive mixture.

Fourthly—It was observed in some experiments that variations in the proportions of the gaseous mixture seemed to have facilitated the passage of the flame to the exterior of the lamp; the Commission were thus led to vary the admission of gas by a studied manipulation of the valve, designated in the tables by the sign "Sch," and which may be thus described. The lamp was first put out by means of a sufficiently strong mixture of gas, which was maintained for several seconds, to heat the metallic parts. The influx of gas was then gradually diminished nearly to the point where the mixture ceased to be combustible; when ordi-

narily, at this moment, either the lamp was totally extinguished, or the flame passed up the chimney into the wire gauze cylinder. In the latter case, the explosion was inevitable, particularly if at this moment the proportion of gas was a little augmented. This succession of circumstances, however artificial it may appear at first sight, can very well occur in mines, where the composition of the gaseous mixtures in circulation is far from being uniform. Relatively frequent explosions have been obtained by this manœuvre, more or less varied according to circumstances and the class of lamp submitted to experiment. It may be concluded for that reason that mixtures containing very little gas facilitate the passage of the flame up the chimney, a fact which is explained, besides, by the small quantity of carbonic acid produced by the combustion of the mixture in the glass cylinder.

Fifthly—The Commission also judged it useful to observe the effect produced on the lamps by inclined currents, either ascending or descending. From want of time, they were not able to make use of the arrangement which had been resolved upon for this purpose; in place of which they made use of a small apparatus that they introduced into the box; it was composed of two small parallel boards, inclined to the horizon at an angle of about 30°, and each pierced with an elliptical opening to insert the lamp. This apparatus produced not only the inflection of the current but whirlings, the existence of which was shown by the oscillations of the flame. It is without any doubt that the disastrous results of experiments of this kind are due to these whirlings, for not one lamp prevented explosion when they were present; and from the observed results, it may be admitted that the employment of the apparatus with inclined currents had the effect of completely changing the action of the combustion in the lamps, the gaseous mixture arriving upon the flame down the chimney, whilst the products of combustion passed away through the horizontal gauze; also that the whirlings, which are produced when a rapid current of air issues out of a cutting or staple, comes rushing into a gallery, create an eminently dangerous combination if the current is more or less charged with gas, and, therefore, miners cannot use too much caution in approaching places where such currents are likely to occur.

Plates Nos. XIV. to XVIII. show the different systems of lamps that have been tried, and the detailed results of the experiments are given.*

* In the original report there are ten pages of tables descriptive of the various lamps which it has not been thought necessary to publish here. Extracts, however, have been made from them and added to the drawings.

Certain lamps which exploded too easily, and certain others which burned badly and were not of a practical construction, were only subjected to a limited number of experiments.

The experiments, as a whole, proved that no lighting apparatus can be considered as absolutely safe. As far as the Davy and Deputies lamps are concerned, it has been observed from the beginning that they give no kind of security in explosive currents moving at a velocity of 7·380 feet per second. Besides, the Commission of St. Etienne had already ascertained that these lamps ceased to be safe in an explosive current moving at a speed of 5·576 feet per second. The Commission therefore employed these lamps when they desired to produce explosions, and also when they wished to ascertain the composition of the mixtures.

The Mueseler lamp, whether made according to the standard or not, generally comported itself well; however, in several cases it produced explosions the determining causes of which were not well known; the special manœuvre "Sch" of the valve, the greasing of the horizontal gauze, swinging, and the ascending whirling currents, also caused it to explode. It was observed that the safety of this lamp rests above all in the narrowness of the top of the chimney, the diameter of which it is advisable to diminish as much as the requirements of practice permit.

Among the various systems derived from the Mueseler type, the lamps, Godin G. and Joassin, were the only ones which have passed through nearly all the experiments without explosion. The first produces little light, compared to the Mueseler, on account of the wire gauze cone which surrounds the flame; by its resistance to the different causes of explosion, and by the persistence with which it preserves its light in explosive mixtures, it may be considered as a good safety-lamp, in cases where it is necessary to penetrate into works where fire-damp exists; but unfortunately it has been observed that this lamp occasions explosions in inclined and whirling currents, either ascending or descending.

Of all the lamps submitted to the experiments, the Mueseler-Joassin lamp has comported itself the best; the ascending and whirling currents, combined with the manœuvre "Sch" of the valve, alone being able to make it fail. But these are the most dangerous circumstances to which a lighting apparatus can be exposed.

Independently of the lamps presented by different inventors, the Commission, acting upon the experience acquired in the course of their work, endeavoured to produce several modifications in the details of the Mueseler lamp; these modifications have been more particularly modifications in the diameter of the top of the chimney, as well as in its shape at the base, and in the distance between the base and the wick tube.

It was observed, as it has already been said, that the narrowness of the upper part of the chimney constitutes a great guarantee of safety, in the Mueseler lamp and in the lamps of which it forms the type; also that the existence or non-existence of a bell-mouthing at the base of the chimney, as well as a difference of a few hundredth parts of an inch in the height at which the chimney is placed above the wick tube, does not essentially modify the safety of the lamp; there is however a shade in favour of the standard chimney.

Another modification consisted in the division of the upper part of the chimney into several channels, in order to obtain a total section sufficient for the escape of the products of combustion, combined with escape orifices of a very small diameter. M. Demanet (who submitted a lamp of this type) agreed with the Commission that this arrangement did not produce any useful results in the inclined and whirling currents.

The Commission also made some tests to ascertain the influence which the nature of the wire gauze had upon the rapidity of the transmission of the flame. These experiments, made by means of the Deputies lamps, did not always give precise results, the explosions in every case taking place in a very short time; nevertheless, the period during which a gauze resisted the explosive influences increased in proportion to the thickness of the wire and the smallness of the mesh.

The lamps submitted to the different experiments were provided either with ordinary glasses or crystal glasses, both furnished by the establishment of Val St. Lambert. The crystal glass cylinders did not resist the overheating any better than those of glass; the fractures which manifested themselves were besides more irregular, and, consequently, more dangerous than those in the ordinary glasses. But it is to be remarked that, whatever the material employed in the manufacture of these glass cylinders might be, the Commission, in the course of numerous experiments, never had a case of explosion due to their rupture, the fragments after fracture remaining in all cases secure in the sockets.

In concluding this report, it was observed that, on account of the short length of the testing box, the gas at its arrival in the lamp, was never in a state of intimate mixture with the air; and it was shown that the state of the atmosphere, the temperature, and degree of humidity of the air, the composition of the gas, its more or less recent make, etc., etc., were some of the causes which may have had an influence on the variation of the results obtained. The dangerous moment of the exposure of a lamp being followed either by an explosion outside the lamp, or by its total extinction, produced by a turning round of the flame, or by a small interior explosion, it may be comprehended that the smallest difference in

the circumstances under which the experiments were made, or the sudden interposition of the slightest current of air of whatever sort, suffices to make a variation in the result. Hence the necessity of the numerous experiments which had been made, and which would from necessity form an important part of the experience upon which the Commission would have to base its judgment.

SECTION I.

The Davy lamps, Fig. 1, Plate XIV., experimented upon were of the following makes, viz. :—French, used in the district of Mons, by Dubrulle, Lille; English, and one with a double gauze and interior glass.

The lamps called "Deputy, or testing lamps," Fig. 2, Plate XIV., were of the following makes, viz. :—Charleroi, with simple gauze, used in the district of Mons, with double gauze Mueseler Liege type, without the chimney, and an English Clanny lamp.

On these lamps the Commissioners observed "that the Davy and deputy lamps, when exposed for two minutes to an explosive mixture of air and lighting gas, moving at a velocity of 4·264 feet per second, do not communicate the flame to the exterior, but when the velocity reaches or surpasses 7·380 feet the explosion is always produced on the outside, save in quite exceptional cases of extinction by asphyxia, caused by the voluntary admission of a large quantity of gas. The Commission did not endeavour to find out at what velocity between 4·264 feet and 7·380 feet the phenomenon of exterior combustion commences to manifest itself; but it has been observed that the explosion takes place after from five to ten seconds when the velocity is 9·840 feet; and after from two to five seconds when the speed is 19·680 feet. Sometimes, at the latter speed, the explosion seems instantaneous. The Davy lamps of the district of Mons, provided with a fine wire gauze (1,354 meshes to the square inch, and wire of ·01 of an inch in diameter), and the Deputy's lamp of the same place, having a double gauze of 1,354 meshes to the square inch, occasioned, during the experiments of the Sub-Commission, ten cases of explosion out of ten experiments, at a velocity of 13·120 feet. In recent experiments made at St. Etienne with the Charleroi Deputy lamp, having a simple gauze of 1,354 meshes to the square inch, and wire ·01 inch in diameter, it was found that they were safe only in a velocity not exceeding 5·576 feet."

Included in Section I. is the Singing lamp of Dr. Irvin, Fig. 3, Plate XIV., of English make, consisting of a bronze chimney, furnished with a glass disc, and terminated by an apparatus (kind of chimney), which,

in case of the combustion of a certain proportion of gas, causes more or less sonorous vibrations. The air is admitted through two gauzes, one of which is under the wick-tube in a horizontal position; and the products of combustion pass out through a small cylinder of wire gauze which surrounds the upper part of the chimney.

The result of the tests made by the Commission in velocities of 4·264 feet and 9·840 feet was an explosion in the latter case; and they observed that this lamp only produced its harmonic alarm sometime after the appearance of the flame had indicated the presence of a large quantity of gas; and even whilst it was burning, the gauze cylinder of a Deputy's or testing lamp was full of flame. At the second experiment it exploded before the warning noise was heard.

SECTION II.

The lamps tested were:—

The Liége Mueseler, made according to the Ministerial Decree of July 10, 1851.
Liége Mueseler, samples A and B, from the Coal Mines of La Haye.
Do. from the Coal Mines of Marihaye.
Do. shortened ·197 ins. at the base, from the Coal Mines of Marihaye.
Hainaut Mueseler, Mons district, from the Coal Mines of l'Agrappe.
Do. Do. old type of the Sub-Commission.
Do. Charleroi, from the Coal Mines of Marcinelle.
Mueseler lamps, with chimneys of ·295 to ·315 inches in diameter at the top.
Mueseler lamps, with chimneys of ·492 to ·551 inches in diameter at the top (made by Dubrulle, of Lille).
Mueseler, Mons district, with Arnould's shield.

GENERAL OBSERVATIONS ON THE LAMPS INCLUDED IN SECTION II.

The Mueseler lamps (general form of which is shown in Fig. 4, Plate XIV.) sent for trial to the Commission were submitted to 294 experiments, made under very diverse circumstances. They gave rise to twenty-seven cases of explosion, and to six or seven cases of the simple passage of the flame into the cylinder, omitting—first, the twelve experiments relative to the lamps Dubrulle, the dimensions of which vary too much from those adopted by the inventor; secondly, forty-four experiments not classed; and thirdly, twelve trials upon the efficacy of the Arnould shield, the following general results were arrived at:—226 experiments gave rise to twenty-two cases of explosion and five cases of the simple passage of the flame into the cylinder.

The examination of the tables shows that out of 226 experiments there were 111 at a velocity of under 19·68 feet, having given at a velocity of 11·480 feet, two cases of explosion and three cases of simple passage of

the flame (the horizontal gauze being dirty), and at 14·76 feet or thereabout, nine cases of explosion—of which two were in inclined currents—by the special "Sch" manœuvre of the valve.

The 115 other experiments were made in velocities approaching 19·68 feet, and gave thirteen cases of explosion and two cases of simple passage of the flame.

The Sub-Commission made seventy-nine experiments at a velocity of 13·12 to 29·52 feet, experiments which were marked by six cases of explosion and two cases of simple passage of the flame. Judging from these experiments, it may be concluded that complete extinction (wick and gas) only takes place in explosive mixtures of air and gas moving at a velocity not exceeding 9·84 feet. As soon as the velocity exceeds 9·84 feet the combustion of the gas shows itself under the horizontal gauze, and continues almost always after the extinction of the wick. Thus, at 19·68 feet out of the 115 experiments, there have only been twenty-one cases of complete extinction, the greatest number caused either by an accidental admission of too much gas, or by little interior explosions. The experiments also show that, as far as the state of the lamps is concerned, the uncleanliness of the horizontal gauze appears to augment the facility of explosion, but as this influence was only remarked in the lamp B, from the Mons district, and as the explosions took place instantaneously, the results may probably be attributed to a mechanical effect upon the draught produced by a chimney excessively depressed upon the wick-tube. The inclination of the lamps, their oscillation in the apparatus before the gas impinges on them, the prolongation of the combustion of the gas after the extinction of the wick under the horizontal gauze for five minutes or so, did not cause any case of explosion or even of simple passage of the flame. It is true that the experiments under these circumstances were few in number. The special manœuvre "Sch" of the valve has been shown to cause explosions rather easily. Indeed, out of sixty-five experiments at 14·760 feet and at 19·680 feet velocity there were eight cases of explosion and one case of simple passage of the flame. The experimentor was able at the later trials to produce one explosion out of every five experiments. Finally, notwithstanding the few experiments made, that the action of inclined currents, and the oscillation of the lamp before the impingement of the gas, considerably augmented the danger of explosion. However, in the latest experiments made in inclined currents, it was observed that these only promote a liability to explosion when they are inflected upwards, as in the testing apparatus, in such a manner as to produce a sensible agitation of the

flame of the wick. It may be added that every circumstance of a nature to disturb the draught of the Mueseler chimney, in other words, every circumstance which manifests itself by a strong agitation, and notably by the crushing down of the flame, must be considered as dangerous. (See the observations relative to the lamps supplied with chimneys having many outlets.)

As far as the construction of the lamps is concerned, it results from the comparative experiments, that the relative security of the lamps lies especially in the narrowness of the chimney at the top, and in the degree of resistance of the horizontal gauze to the penetration of the flame. It would moreover appear, that the over-elevation of the base of the chimney above the wick-tube as well as the omission of the bell-mouthed widening, slightly diminishes the safety of the lamp. But according to what has already been said above, an excessive depression of the chimney upon the wick-tube may also be hurtful.

The effect of the Arnould shield upon the Mueseler lamp essentially consists in retarding the moment of the extinction of the wick. This extinction requires a large proportion of gas, and is almost always followed a few seconds after by the extinction of the gas under the horizontal gauze, gas which never fails to catch fire there, and which, notwithstanding its volume is small, continues to burn in lamps deprived of the shield.

If these results are compared with those furnished by the Davy and Deputy's test lamps, it must be inferred that the Mueseler lamp is the best, and that its superiority is particularly noticeable in rapid currents, but it does not afford absolute security.

SECTION III.

MUESELER-THONARD LAMPS.

On the horizontal gauze of the ordinary Mueseler chimney there is placed inside the gauze cylinder a truncated cone of copper, open at the top and designed to break the current of air. Fig. 5, Plate XIV.

These lamps were submitted to seventy-eight experiments, which are subdivided as follows:—Fourteen experiments with a velocity of from 6·560 to 13·12 feet, which occasioned no explosions nor any case of the simple passage of the flame into the gauze cylinder.

Sixty-four experiments with a velocity of 19·68 feet caused three cases of explosion, and also three cases of simple inflammation of gas in the gauze cylinder.

The Sub-Commission made nineteen experiments in velocities varying from 9·84 to 29·52 feet, resulting in one case in the simple passage of the flame into the cylinder.

It is clear from this that the lamps stood the tests much better than the ordinary Mueseler. The special manœuvre "Sch" of the slide valves, and the oscillation of the lamps before the explosive mixture reached the lamp, again facilitated the passage of the flame.

The Mueseler lamp furnishes a much greater number of cases of complete extinctions than the Thonard lamp, but in the latter the combustion of the gas under the wire gauze is most active. In fact out of sixty-four experiments at a velocity of 19·680 feet, the latter lamp was only completely extinguished eight times.

SECTION IV.

MUESELER-JOASSIN LAMP, No. 1.

On the horizontal gauze of the Mueseler chimney (with a diameter of ·318 to ·354 inches at the top) is placed within the gauze cylinder, a conical wire gauze fastened to the chimney at a height of 1·023 to 1·259 inches, which offers a second obstacle to the passage of the flame. Fig. 1, Plate XV.

These lamps were submitted to eighty-two experiments. One, which was exposed to all the trials most likely to cause explosion, only furnished two cases of a simple passage of the flame into the gauze cylinder, and one case of explosion; and these several cases only took place with an ascending current. It resisted all the conditions of the special manœuvre "Sch" of the valve, of the prolonged duration of the experiments to five or six minutes, and of the oscillation of the lamp. However, one other sample, with a chimney narrowed at the base, exploded when caused to oscillate.

There were fourteen complete extinctions out of sixty-two experiments in a velocity of 19·68 feet.

The Mueseler-Joassin lamps were those which were the most to be relied on, considering the number and variety of the experiments.

SECTION V.

MUESELER-DEMANET LAMP.

Under the horizontal gauze of the ordinary Mueseler chimney, and within the glass cylinder, an inverted gauze cone is fastened to the lower part of the chimney at a distance of ·708 inch below the horizontal gauze. Fig. 2, Plate XV.

This lamp was submitted by the Commission to forty-three experiments made in a velocity of 19·68 feet of the explosive mixture under

sufficiently varied circumstances. The experiments only caused one case of explosion. The lamp, amongst all those which were tested, was the most subject to total extinctions, twenty-five out of forty-three experiments.

The Demanet lamp was experimented on fifteen times by the Sub-Commission in velocities of 9·840 to 29·520 feet, which caused one explosion at the latter velocity, and also many total extinctions.

SECTION VI.

MUESELER-JOASSIN No. 2 LAMPS.

This is the same as the Mueseler-Joassin lamp No. 1, with the horizontal gauze replaced by a second gauze cone, like the one in the Mueseler-Demanet lamp. Fig. 3, Plate XV.

The particular disposition of these gauzes allows of their being separated, and consequently they can be easily and perfectly cleaned. Nine experiments were made in a velocity of 19·680 feet, without causing any explosions, but in every case the lamp was extinguished.

SECTION VII.

MUESELER-GODIN G LAMPS.

The wick is isolated in the interior of the glass cylinder by a truncated cone of wire gauze, the base of which presses on the oil reservoir of the lamp, and the upper part penetrates into a Mueseler chimney of ·315 inch in diameter at the top. Fig. 4, Plate XV.

This lamp, after the Joassin No. 1, was subjected to the greatest varied experiments. Out of forty-two experiments made in a velocity of 19·68 feet per second it did not produce a single exterior explosion except in ascending or descending inclined currents, and it resisted all conditions of duration, of oscillation, and of the special working "Sch" of the valve.

A certain number of experiments, classed among the ordinary conditions, were made by altering the valve with a view to find out the particular mode of admitting the gas which was most likely to cause an explosion. After the extinction of the wick, which required a large proportion of gas, the gas burned inside the wire gauze cone, and when the velocity of the current rose to 19·68 feet, there were only six complete extinctions of the lamp out of forty-two experiments.

The breakage of the glass is rare; even without glass, the lamp remains safe in inflammable mixtures moving at a low velocity.

SECTION VIII.

MUESELER-ARNOULD, No. 1.

The chimney is formed of two truncated cones united at the height of the horizontal gauze, and covered near the top by a horizontal gauze. Fig. 1, Plate XVI.

This lamp was often put out at once in strong and plunging currents. One variation gave a bad light on this account, and also because of the fineness of the top gauze (1,161 meshes to the square inch); and this was the same with another sample when the glass cylinder was accidentally too thick, and curtailed too much the passage of the air between the glass cylinder and the bell-widening of the base of the chimney.

Moreover, the combustion of the gas being thrown back by the bell-widening against the glass, caused its fracture to become relatively much more frequent.

Another sample, however, did not present these defects.

The Mueseler-Arnould lamp was submitted to many experiments in explosive currents moving at a velocity of 19·680 feet. Here again some experiments, classed amongst the ordinary ones, were made whilst trying to work the valve in order to produce an explosion.

Out of thirty-six experiments it only caused one explosion and two cases of combustion in the interior of the chimney.

SECTION IX.

MUESELER-ARNOULD No. 2 LAMP.

In this lamp the chimney is of the same general shape as the preceding one, with the addition of a small Mueseler chimney inside. Fig. 2, Plate XVI.

The lamp burned properly, and was less easily extinguished than the preceding one in plunging currents. Out of ten experiments it caused two cases of explosion.

SECTION X.

MUESELER-GODIN C LAMPS.

Here the wick is separated from the interior of the glass by a crystal prolongation of the chimney, resting on a copper gallery perforated with small holes. The chimney is of the ordinary Mueseler types, ·334 inch diameter at the top and slightly shortened at the base. Fig. 3, Plate XVI.

This lamp is one of the varieties of lamps with isolated flame presented by M. Godin, which gave relatively good results in the experiments made by the Sub-Commission. When the samples with a chimney half

crystal and half tin only are considered, the thirty-eight experiments to which these lamps were submitted occasioned only one case of explosion; but the isolation not being perfect, the gas was several times seen to burn between the two glasses under the horizontal gauze, and the method of isolation by a horizontal wire gauze or with perforated copper, both of which being apt to become dirty, would lead to the supposition that in practice the light would be bad.

The isolation of the wick in the Arnould Nos. 1, 2, 3 lamps, tried by the Commission, seems to be carried out in a more rational manner.

As to total extinctions, they were rarely produced when the velocity of the mixture reached 19·68 feet.

SECTION XI.

MUESELER-GODIN D LAMPS.

The same lamp as the preceding one, excepting that the copper gallery is replaced by small studs to support the interior glass, which consequently ceases to completely isolate the wick. Fig. 4, Plate XVI.

This lamp is of a more practical construction than the preceding one. However, out of thirty-two experiments under the conditions stated above, of which seventeen were at a velocity of 19·68 feet, it occasioned three cases of explosion. It was also submitted by the Sub-Commission to thirteen experiments made with a velocity of 11·480 to 14·760 feet, and occasioned three explosions.

SECTION XII.

MUESELER-GODIN H LAMPS.

Sample with cylinder entirely of gauze, and sample with cylinder half gauze and half tin, both furnished with a Mueseler chimney with a second horizontal gauze. Fig. 1, Plate XVII.

Out of seven experiments in a velocity of 19·680 feet, this lamp occasioned one explosion, and not one case of simple extinction.

During the experiments by the Sub-Commission with samples of this lamp, in velocities of from 9·840 to 29·52 feet, two cases of explosion and six cases of simple combustion of gas in the cylinder were occasioned.

Sample with the cylinder half gauze and half tin. This lamp burned very badly and gave very little light, which caused the Commission to abandon their experiments with it.

SECTION XIII.

MUESELER-HARMEGNIES No. 5 LAMP.

A Mueseler chimney furnished in the interior of the glass with an inverted truncated cone of tin, joining the lower side of the chimney to

the side of the horizontal gauze (almost in the same way as the truncated cone of wire gauze of the Mueseler-Demanet lamp). This truncated cone partitions off a certain cavity A under the horizontal gauze, from whence a large tube descends almost to the level of the wick to feed the flame. Fig. 2, Plate XVII.

The construction of this lamp prevented the Commision seeing what occurred after the extinction of the wick, and, after making three trials, resulting in one explosion, they did not think that it was necessary to continue the experiments.

The Sub-Commission obtained one explosion out of seventeen experiments.

SECTION XIV.

MUESELER-HARMEGNIES No. 6 LAMP.

The lower cone of No. 5 is suppressed and the horizontal gauze is replaced by a disc of tin from whence the tube A starts to feed the wick. A wire gauze cone similar to that of the Mueseler-Joassin is laid on the edge of this disc and fastened to the chimney near the top. Fig. 3, Plate XVII.

The Commission obtained two explosions from two trials in a velocity of 19·680 feet and did not continue the experiments.

SECTION XV.

MORISON LAMP (TWO SAMPLES SLIGHTLY DIFFERENT).

In this class of lamp there are two glasses as in the old Rocour lamp, and the wick is isolated by an interior glass. It has the sheet iron chimney of the old Elvin lamp, surmounting the interior glass; this chimney is formed of two truncated cones united at their smallest bases at a distance of, in one case 2·362 inches, and in another 1·259 inches, above the horizontal gauze. The fittings are joined by screws and nuts. Fig. 4, Plate XVII.

These lamps are of a very complicated construction, give a very bad light in stagnant air, and were extinguished in the testing apparatus by the plunging current of air coming from the trap door. Out of eleven experiments at a velocity of 19·68 feet, these lamps caused neither exterior explosions nor any inflammation of gas in the exterior cylinder. There were five complete extinctions; but some of them only might have been apparent because it was impossible to see under the lower gauze.

The combustion of the gas filled the whole of the internal glass at times; it was often confined to the base and there were probably cases where it burnt without passing the lower gauze. Several parts of the lamp were unsoldered by the heat.

The Sub-Commission submitted these lamps to nineteen experiments in explosive currents moving at a velocity of from 13·129 to 29·520 feet per second, with the same results, but it was also remarked that the ignited gas passed the bottom gauze, entered between the two glasses, and burnt under the upper horizontal gauze.

SECTION XVI.

MORISON-ARNOULD LAMP (TWO SAMPLES SLIGHTLY DIFFERENT).

Morison lamp modified, made more in the form of the ordinary Mueseler lamp, and of a construction more practical than the preceding one, but they still burn with difficulty, and are easily extinguished, particularly one sample where the interior gauze near the top part of the chimney had a very close mesh. Fig. 1, Plate XVIII.

Out of eight experiments these lamps did not cause any case of explosion or of passage of flame into the cylinder. There was not a case of total extinction, and the flame in one of the experiments made with the other sample appeared to have passed between the two glasses.

SECTION XVII.

LAMPS WITH CHIMNEYS AND NUMEROUS TUBES.

In these the chimneys were furnished with the two cones of wire gauze of the primitive Mueseler-Joassin No. 2 lamp; they are in two pieces to permit the cleaning of the two cones. Figs. 2 and 3, Plate XVIII.

The tubes are in clusters tangential to one another and leave between them other little passages. These clusters can easily be taken off for cleaning.

MUESELER-JOASSIN No. 2 LAMP WITH TUBULAR CHIMNEY.

One specimen had in the interior of the chimney and at 1·023 inch from its extremity, a cluster of three small tubes of 1·063 inches in height, and of ·196 inch minimum diameter. (Fig. 2, Plate XVIII.)

Another specimen had in the interior of the chimney and at ·708 inch extremity a cluster of small tubes of ·984 inch in height and of ·167 inch minimum diameter.

Another specimen had in the interior of the chimney at ·708 inch from the top a cluster of small tubes of ·866 inch in height and ·130 inch minimum diameter.

In another specimen the top part of the chimney has a square section containing four long immovable tubes of 1·889 inch in height and of ·187 inch minimum diameter. The chimney might have been divided into small passages according to the axis. Fig. 3, Plate XVIII.

MUESELER-DEMANET WITH CHIMNEY AND NUMEROUS TUBES.

Chimney in one piece, provided with the two gauzes of the primitive Mueseler-Demanet lamp and terminated at its extremity by a copper cylinder of ·787 inch in height, perforated with six slightly conical holes of ·157 inch minimum diameter. Fig. 4, Plate XVIII.

These lamps all behaved nearly in the same manner. They light properly ; but they seem to be easily extinguished in ascending currents. There has only been one case of simple total extinction ; but the tests have not been prolonged after the slide door was brought to and maintained at a fixed point. Putting aside five experiments made in horizontal currents and in conditions resulting from the special manœuvre "Sch" of the valve, experiments, which, concurrently with those principally undertaken on the primitive Mueseler-Joassin lamp, show the extreme difficulty that there would be in producing explosions in such currents with lighting apparatus provided with multitubular chimneys such as the above, all the experiments have been in ascending currents which had previously been found eminently dangerous.

In ascending currents every one of the multitubular lamps contributed one case of explosion in a velocity of 19·680 feet, but it was noticed that each time an explosion took place the position of the lamp experimented on was such that before the arrival of the gas the flame of the wick was found to vacillate strongly or to be crushed down on the wick, which indicated the presence of whirling currents or eddies in the moving mixture whereby a sudden ascending inflection was produced in the currents just as it began to impinge on the lamp. Thus the frequency of the explosions was much oftener caused by these whirlings or eddies than by the simple velocity of the current, and the whole of the experiments made by the Commission prove that only those circumstances may be considered as dangerous which reverse the currents of air and cause them to flow in a different manner to that which the lamp was designed to produce, and this reversal of the current is made manifest by the agitation and beating down of the flame.

Lighting of Fiery Mines.—Royal Decree of the 17th June, 1876.

REPORT TO THE KING.

Sire,—For more than half a century laudable efforts have been made, as well in Belgium as in other countries, to find a mode of lighting fiery mines without danger.

These efforts have not been without results.

A first and remarkable result was obtained in 1815 by the invention of the Davy lamp.

Received at first with distrust, the Davy lamp however did not fail to make rapid progress, and for a certain time it was considered an infallible preventative against an explosion of fire-damp. Later experience proved that its merit had been a little exaggerated, and that it possessed certain imperfections. Numerous endeavours had been made to obviate these, when in 1840 a Belgian mining engineer, the late M. Mueseler, offered a safety-lamp of his invention to a Commission charged by the Department of Public Works to make comparative trials of the principal apparatus in use for lighting mines.

This Commission came to the conclusion that the Mueseler lamp combined, in a greater degree than all those submitted to their examination, the essential conditions of a good safety-lamp. However, they thought it well to await the results of its practical use before definitely deciding the question.

During the first few years the new apparatus was but partially used, and the Government thought it their duty to encourage the inventor by granting him a subsidy which enabled him to reduce the price.

In 1851 the Mueseler lamp was allowed, along with others, to be used in lighting fiery mines until actual practice would permit of a judgment being formed on the relative merits of each system.

At length, in 1864, it was acknowledged that the Mueseler lamp was the one whose employment presented the greatest security for the miners, and by a Ministerial Order of the 29th of April, of the same year, the use of it was declared obligatory in fiery mines.

But the Department of Public Works having been petitioned since that time to decide upon the employment of new safety-lamps, of which several used mineral oil (petroleum), instituted, by an order dated the 20th of January, 1868, a Commission charged to proceed with a comparative examination of these lamps and of those of which the use was already authorized.

This Commission, after numerous and lengthened experiments (see the account of these experiments, Vol. 31, pages 306 to 517, of the "Annales Travaux Publics"), reported that the Mueseler lamp, fed with vegetable oil, is in every respect superior to all the others submitted to its examination.

In consequence, it concluded that this lamp should be the only one admitted for the lighting of fiery mines, except the Mueseler-Godin, the large Mueseler, and the Deputy's or testing lamp.

As to mineral oils, the Commission thought that by their nature, and the great variation in their composition, they were too dangerous for their use to be authorized in fiery mines.

I can only endorse these conclusions, which appear to me plainly justified, and I think it my duty in consequence to propose to your Majesty to approve of them.

The orders concerning the lighting of fiery mines being at present contained in several general and provincial regulations, I think that it would be useful to unite them in one decree only, in order to make the whole of them better appreciated, and thus facilitate their application.

The annexed decree having been conceived in accordance with the preceding remarks, I hope that your Majesty will deign to favour it with your sanction.

The Minister of Public Works,

A. BEERNAERT.

LEOPOLD II., KING OF THE BELGIANS.

TO ALL PRESENT AND TO COME, GREETING.

With regard to the Royal Decree of the 11th of August, 1841, and 29th of June, 1844, and 7th of July, 1847, approving the laws concerning the lighting of fiery mines in the provinces of Hainaut and Liége;

With regard to the Articles 11 to 15 of the Royal Decree of the 1st of March, 1850, relative to the lighting of the fiery mines of the kingdom;

With regard to the Ministerial Orders of the 29th April, 1864, declaring that the Muesler type of lamp is obligatory for the lighting of the said mines;

With regard to the report of the Special Commission, instituted by the order of our Minister of Public Works, dated 20th of January, 1868, for a comparative examination of safety-lamps fed by mineral and vegetable oil;

Considering that it results from this report, and the experiments to which the different lamps have been submitted, that the Mueseler lamp is, amongst all others, the one which presents in actual use the greatest security for the miners;

Considering that it is important to the safety of the working miner, and for the protection of the works, to put a stop to the employment of Mueseler lamps modified in form so as to diminish their efficacy;

Considering that for the same motives it is desirable to prevent the the employment of explosive oils in the interior of fiery mines;

Wishing to reunite in a single decree the different statutes and regulations relating to the lighting of fiery mines;

With regard to the laws of the 21st April, 1810, and the decree of the 3rd January, 1813, upon mines;

With regard to Article 67 of the Constitution;

On the proposition of our Minister of Public Works,

WE HAVE DECREED AND DO DECREE:

ARTICLE 1.—That no other than the Mueseler type of lamp, fed with vegetable oil, conforming to Fig. 1, Plate XIX., joined to the instructions annexed to the present decree, be permitted to be used in lighting fiery mines. In order to facilitate the employment of this lamp, it may be varied according to the modifications indicated in the instructions by the letters A, B, C, D, E, F. Fig. 2, Plate XIX.

ARTICLE 2.—No other apparatus or mode of lighting will be allowed without a prior authorization of our Minister of Public Works, except as follows:—

A.—The agents appointed for the inspection of the works, and who are not employed as workmen, can make use of the Mueseler-Godin lamp, with interior glass, simply supported without a protecting gauze or bottom support. Fig. 3, Plate XIX.

B.—For the fixed lighting of shafts and some hanging-on places, ventilated by pure air coming direct from the surface, the mining engineers can permit the use of lamps of the Mueseler design of a larger size than the type, fed by vegetable oil. Plate XX.

C.—The chief mining engineers can, in any particular case, permit provisionally mining engineers, overmen, back overmen, and deputies, the use of the lamp called the Deputy's or testing lamp when made of the prescribed dimensions, with a double gauze of at least 1,451 meshes to the square centimetre, the metallic thread having a diameter of ·01 inch. (No. 20 wire gauge of Liége, or No. 30 English gauge).

ARTICLE 3.—The safety-lamps must be made to lock, and when not in use remain deposited in the lamp house. Special agents must take care to see that each lamp is of the type admitted or tolerated by the Administration of Mines; they are besides charged to examine them and cause them to be cleaned each day and maintained in good condition by experienced workmen.

ARTICLE 4.—At the time of descending, a lamp is to be given to each workman, who must assure himself that it is locked.

ARTICLE 5.—The lamps which go out in the mine must be sent either to the surface, or to some place in the mine, where they are to be examined, re-lit, and re-locked by men expressly charged with this duty, and under the supervision and direction of the overmen and deputies.

The stations where the lamps are to be re-lit are, at the instance of the inspecting engineers, fixed by colliery engineers entered in the standing orders of the mines, in conformity with Article 31 of the Act of March 1st, 1850.

ARTICLE 6.—It is strictly forbidden to open lamps in any part of the mine excepting in the places appointed by the management.

ARTICLE 7.—Every workman who carries an unlocked lamp, or any instrument by means of which his lamp can be opened, is to be immediately taken in charge either by duly-sworn special watchmen, or by the officers of the mine, or by the local police, and the particulars of the offence committed to writing.

ARTICLE 8.—It is forbidden to smoke in the mine. Every miner who carries a pipe, steel, or match, or any other article with the object of obtaining a light, is to be dealt with in accordance with article 7.

ARTICLE 9.—The term fiery mine is applicable to those places which come under Article 31 of the Act of March 1, 1850.

ARTICLE 10.—When fire-damp appears in a drift or level in sufficient quantity to cause a continuous lengthening of the flame in the lamps, work must be immediately suspended until the danger has passed away.

ARTICLE 11.—All objections which may be urged against the carrying out of these laws, as well as petitions for delay in putting them into execution, must be addressed to the permanent deputation of the Provincial Council, who will decide upon them after having taken the opinion of the chief mining inspector.

Appeals against the decisions of this tribunal, whether they are on behalf of the Government engineers, or on behalf of the proprietors of mines, must be addressed to our Minister of Public Works.

ARTICLE 12.—A pattern lamp of each of the systems permitted or tolerated is to be deposited at the Department of Public Works as well as in each sectional bureau and mining district.

In all that concerns the dimensions and forms of the essential parts of the lamps, the instructions annexed to the present decree must be strictly conformed to.

A sufficient number of gauges to ascertain the number of meshes and the size of the wires in the metallic gauzes will be placed at the disposal of the mine officials.

ARTICLE 13.—Infractions against the provisions of the present decree are verified, prosecuted, and judged conformably to Code X. of the law of the 21st April, 1810, relating to mines, minerals, and quarries.

ARTICLE 14.—The present regulations must be affixed by the directors or proprietors of fiery collieries in a place accessible to the workmen.

ARTICLE 15.—The orders relative to the lighting of mines contained in the Royal decrees aforesaid, of the 11th August, 1841, 29th June, 1844, and 7th July, 1847, and in the Ministerial Order of the 29th April, 1864, are repealed.

Our Minister of Public Works is charged with the carrying out of the present decree, which will be inserted in the "Moniteur," as well as the instructions above mentioned.

Given at Brussels the 17th June, 1876.

LEOPOLD.

By the King:
The Minister of Public Works,
A. BEERNAERT.

LIGHTING OF FIERY MINES.—INSTRUCTIONS ANNEXED TO THE ROYAL DECREE, JUNE 17TH, 1876.

I.—Mueseler pattern lamp, Fig. 1, Plate XIX., dimensions and forms of the essential parts. Drawing No. 1, A.—Glass cylinder, furnished at its ends with metallic ring sockets, the upper socket covering the edge of the horizontal gauze:—

Exterior diameter	2·364 inches.
Thickness	·216 „
Height, including lower socket not more than	2·442 „

B.—Inside chimney of thin iron. Conical tube widened into a bell-shape at the base:—

Interior diameter at the top not more than	·394 inches.
Do. at the base not more than	1·182 „
Do. at the commencement of the widening not more than	·985 „
Height of that part of the chimney above the horizontal gauze	3·546 „

Height of the part of the chimney under the horizontal gauze, comprising the bell-widening at the base ...	1·063 inches.
Height of the bell-widening at the base	·236 „
Distance from the base of the chimney to the top of the wick tube	·866 „

C.—Cap of wire gauze; a closed envelope of cylindrical form surmounting the glass:—

Height	4·294 inches.

D.—Wire gauzes (of the cap and the horizontal gauze) made with wires of at least ·013 of an inch in diameter, with a minimum of 928 meshes to the square inch.

With the view of lessening the difficulties which would present themselves in practice by the rigorous observance of the dimensions ordered in the foregoing, the following margin is allowed:—

A.—For the exterior diameter of the glass ·039 of an inch more or less.

B.—For the thickness of the sides of the glass ·019 inch more or less.

C.—For the length of each of the parts of the chimney taken from the horizontal gauze as well as for the distance which separates the base of the chimney from the top of the wick carrier, ·078 inches more or less.

The chimney is only limited in height from the horizontal gauze in order to facilitate the examination of the roof of the workings for fire-damp.

D.—Suppression of the bell-shaped widening at the base of the chimney, which must not in this case exceed 1·024 inches in the lower diameter.

E.—For the height of the gauze cap ·157 inch more or less.

F.—Reduction of the diameter of the wire of the gauze even to ·009 of an inch when the number of meshes attain or exceed 1,451 to the square inch.

II.—Drawing No. 3.—Mueseler-Godin lamp, for overmen charged with the superintendence of the works, and who are not employed as workmen. Fig. 3, Plate XIX.

III.—Drawing No. 4.—Mueseler lamp, large size, for the fixed lighting of shafts, etc. Plate XX.

A.—Cylindrical glass.

Exterior diameter	2·364 to 2·758 inches.
Thickness	·216 to ·315 „
Height not more than	3·937 „

B.—Conical chimney :—

Diameter at the top, maximum	... ...	·591 inches.
Do. at the base do.	... ...	1·379 „

Height of the part above the horizontal gauze at least 3·546 inches, when the mean of the diameters at the top and at the base does not exceed ·788 inches, and ·393 inches of increase of height for each ·039 inches in diameter, which shall be in excess of this mean.

It follows, therefore, that for the maximum diameter of ·591 inches at the top, and of 1·379 inches at the base, the height of the part of the chimney above the horizontal gauze should be at least 5·516 inches

$$3{\cdot}546 + \left(\frac{{\cdot}985 - {\cdot}788}{{\cdot}039}\right) = \frac{{\cdot}197}{{\cdot}039} = 5 \times {\cdot}393) = 5{\cdot}516.$$

Height of the part below the horizontal gauze, to be at least equal to half the distance of the said gauze from the top of the wick carrier.

In taking the case of a lamp furnished with a glass of 3·940 inches in height, and provided with a wick tube elevated ·945 inch above the lower edge of this glass, the distance from the base of the chimney to the horizontal gauze ought to be at least half of 2·995 inches, or 1·497 inches.

C.—Wire gauzes.

The same gauzes as for lamps of ordinary make.

In order to prevent the horizontal gauze of the cap becoming quickly impaired by the heated air from the chimney, the latter can be furnished with a thin iron apparatus (see the plate) designed to break the current of warm air a little beneath the said gauze.

The drawing No. 4 before mentioned represents a lamp of the maximum form, in accordance with the dimensions given above.

The lamp may be advantageously provided with a reflector and a feeding reservoir at a constant level.

IV.—Construction and maintenance of lamps.

Lamps should be constructed and maintained with care. Their different parts should be well fastened into the framework; the cap or outside covering of wire gauze should fit exactly to the glass, which should fit perfectly on the reservoir.

The custom adopted in many mines of numbering the lamps, and assigning every day to the same workman the same lamp, not only assures their good preservation, but realizes an excellent check on the numbers of the people in the works. It is important also for the maintenance of the lamps in good condition that they be kept in repair by a well-qualified lamp inspector employed at the colliery, and not given to a lamp contractor to keep in order.

The drawing No. 1 gives the proportions of the pieces generally adopted in the basin of Liége; the drawing No. 2 those more particularly in use in the basin of Hainaut.

Besides the instructions before mentioned, the following recommendations may be made:—

A.—The reduction of the diameter of the chimney at the top.

This reduction augments the safety of the lamp especially in inflammable currents travelling at a high velocity.

B.—The employment of the cone of wire gauze touching the chimney a certain height above the horizontal gauze, and being fitted on its lower edge to the circumference of the gauze (Joassin arrangement). Figs. 1 and 2, Plate XXI.

C.*—The isolation of the wick to the interior of the lamp by the Godin cone of wire gauze, springing from between the glass and the lower socket, and entering, a tight fit, within the thin sheet iron chimney. Fig. 3, Plate XXI.

The sample of the Mueseler-Joassin lamp, which, during the numerous experiments made by the Commission, presented such a superior degree of security, had ·334 inch diameter at the top.

D.—The isolation of the wick by an interior glass, whose lower edge fits into a space separated by wire gauze, and the upper part of which fits by friction inside the thin iron chimney cut off at its base (combined design of Arnould and Godin). Fig. 4, Plate XXI.

The examples of lamps with the flame isolated to the interior of the glass, which, submitted to the experiments, have given results relatively favourable, had ·334 and ·354 inch diameter at the top.

V.—Rapid currents of air. These currents are particularly dangerous when their action manifests itself by the crushing of the flame upon the wick. Indeed, the relative security of the Mueseler lamp does not depend alone on the smallness of the section of the chimney, especially at the top, or on its height, but rests essentially in the regularity of the draught. It is also to be remarked that when by any cause whatever the supply of air happens to reverse in the interior of the lamp, a circumstance which shows itself by the crushing of the flame under the chimney, the inflammation of the gas extends itself with the greatest facility into the upper cap.

* The examples C and D are recommended for lighting certain dangerous workings, and especially where there is any danger of the breakage of the glass.

B and C are council orders, notably for the lighting of workings with a sharp ventilating current and much dust.

The responsible agents of the collieries ought to watch that the workmen handle the lamps with prudence, and that they do not expose them either to concussion or irregular motions. They should be held as much as possible sheltered from rapid currents, particularly currents producing a strong vacillation of the flame.

Apart from the explosions which occurred during the experiments made by the commission in an inflammable mixture moving at a high velocity, it suffices here to record that when this speed equalled 9·840 feet per second the gas almost always continued to burn under the horizontal gauze.

VI.—The Commission insists on this important point, that the Mueseler lamp, in every way superior to the Davy and other apparatus of the same kind, presents, nevertheless, like all other so-called safety lamps, only a relative security. It is then, in fact, only an auxiliary apparatus, necessary in fire-damp mines to complete a state of security which should depend principally on active ventilation and a good laying out of the workings.

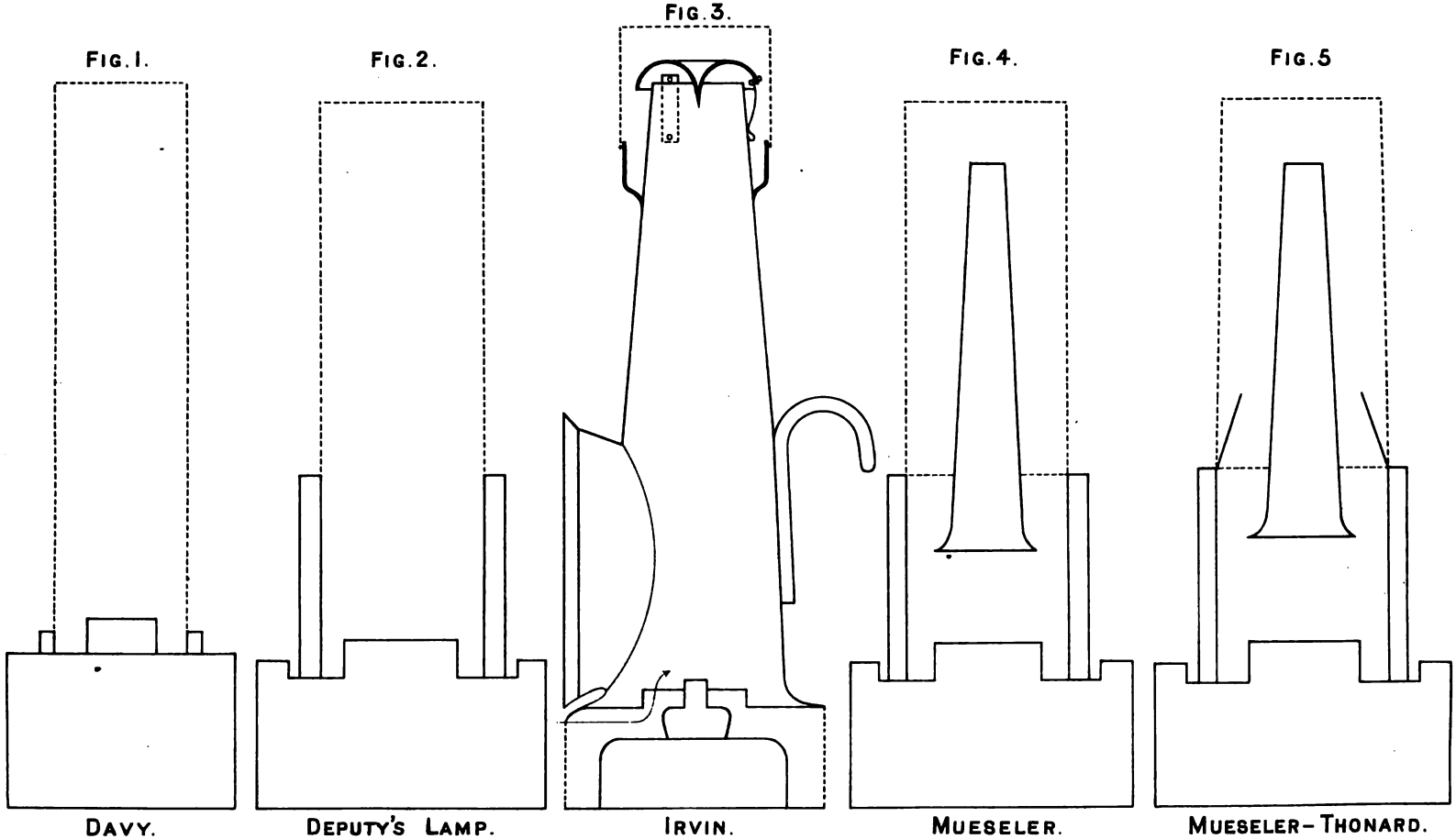
It is to be observed, further, that variations in the temperature of the air at the surface and in the atmospheric pressure can exercise a disastrous influence on this security. It is expedient that each mining centre should be provided with the proper instruments to ascertain the state and temperature of the atmosphere. The officers of the mines will indicate the position where the barometer and thermometers must be placed, and the nature of the observations to be taken every day.

Approved to be annexed to our Decree of the 17th June, 1876.

LEOPOLD.

By the King:
The Minister of Public Works,
A. BEERNAERT.

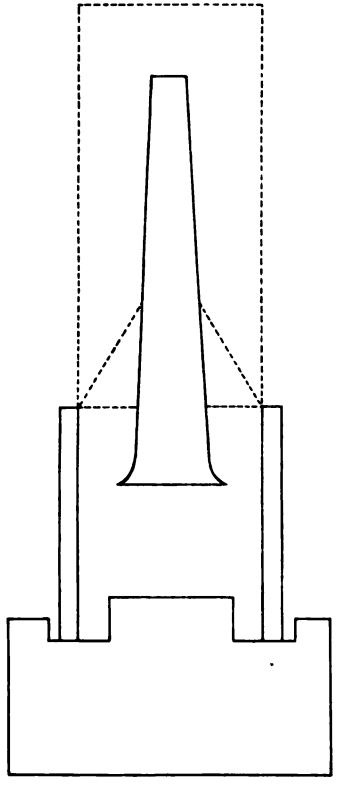
To illustrate the Report of the Belgian Commission on Safety Lamps.–Translated by Mr C.G. Jackson.



And.w Reid, Sc.

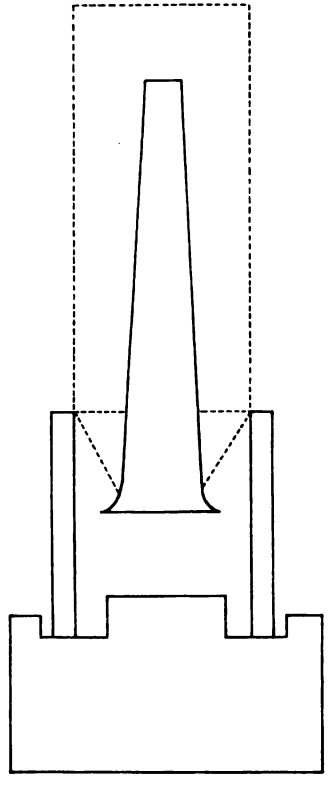
To illustrate the Report of the Belgian Commission on Safety Lamps.—Translated by Mr. C. G. Jackson.

Fig. 1.



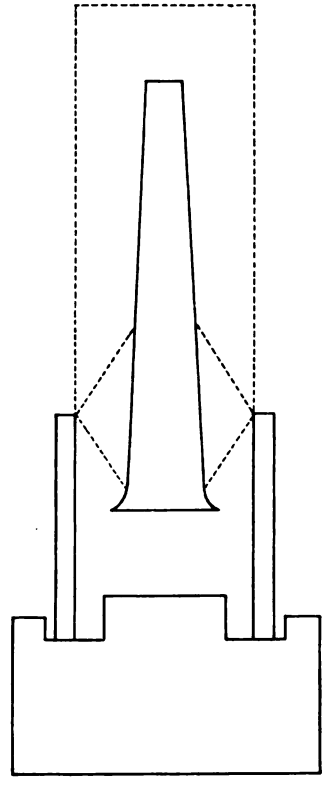
Mueseler-Joassin. No. 1.

Fig. 2.



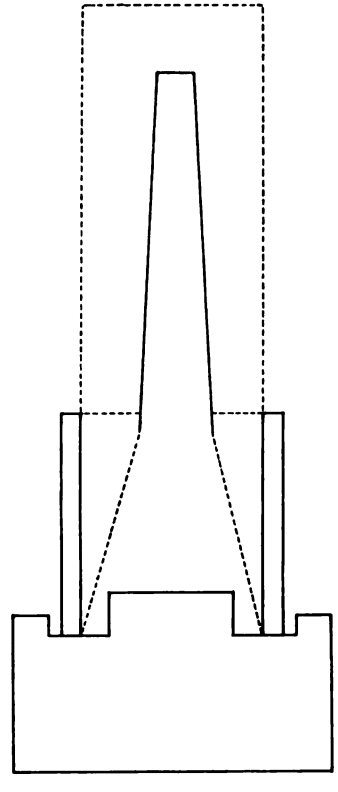
Mueseler-Demanet.

Fig. 3.



Mueseler-Joassin. No. 2.

Fig. 4.



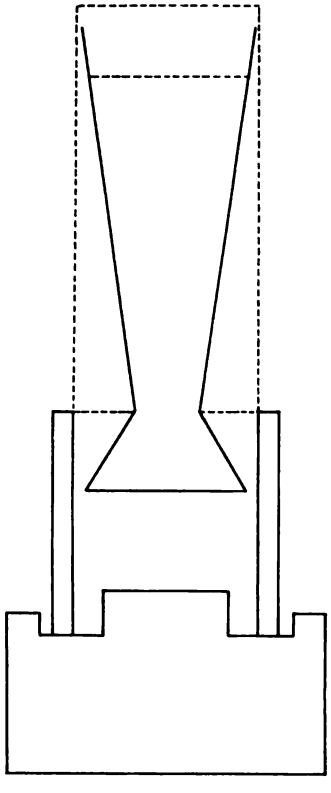
Mueseler-Godin. G.

Proceedings No. E.I. of M.M.E. 1879-80)

A. & M. Read, Newcastle.

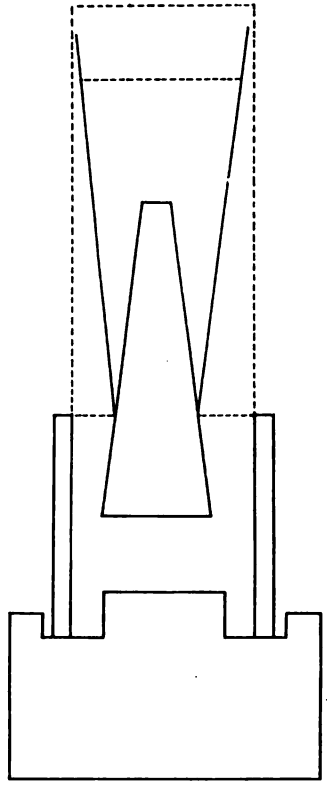
To illustrate the Report of the Belgian Commission on Safety Lamps. - Translated by Mr C.G. Jackson.

FIG. 1.



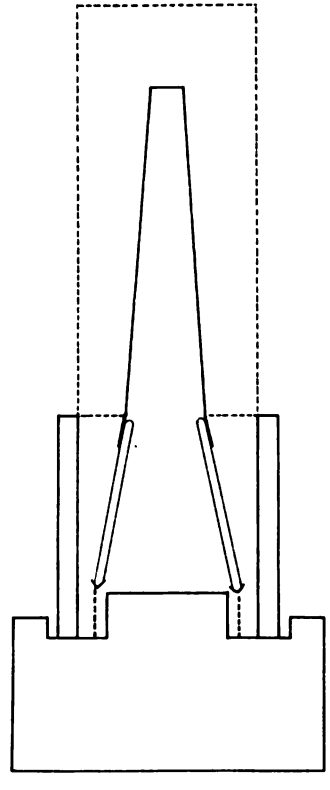
MUESELER-ARNOULD. Nº 1.

FIG. 2.



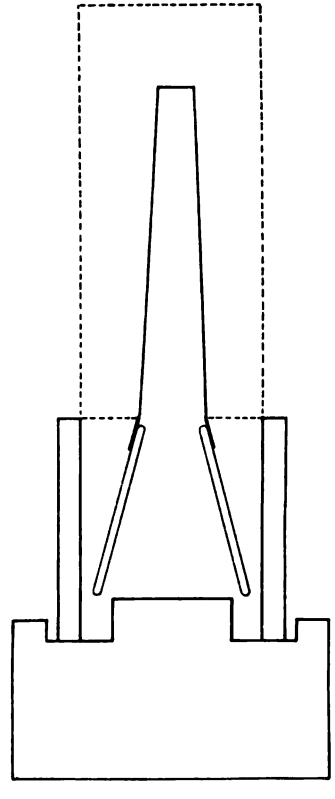
MUESELER-ARNOULD. Nº 2.

FIG. 3.



MUESELER-GODIN. C.

FIG. 4.

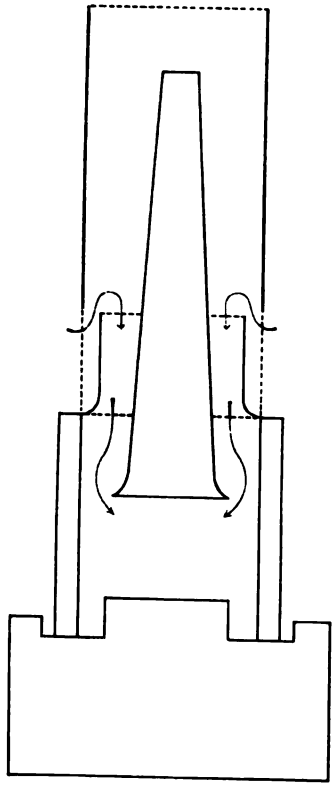


MUESELER-GODIN. D.

Proceedings Nº E.I. of M.&M.E. 1879-80.

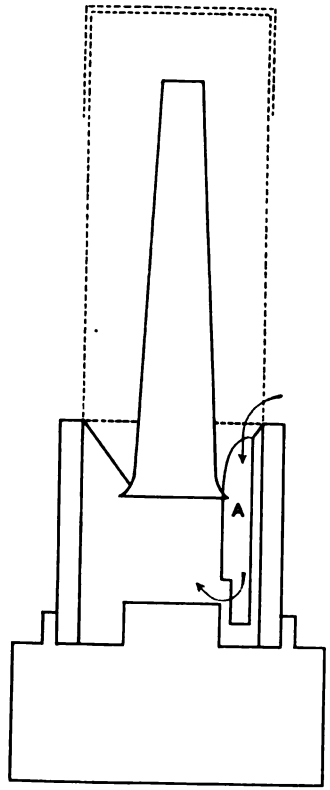
To illustrate the Report of the Belgian Commission on Safety Lamps.- Translated by Mr. C. G. Jackson.

Fig. 1.



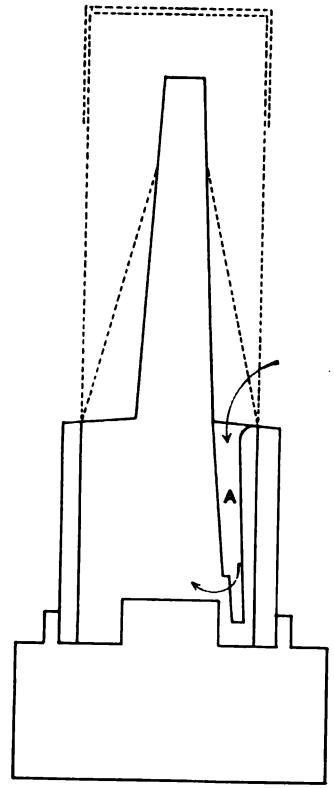
Mueseler-Godin. H.

Fig. 2.



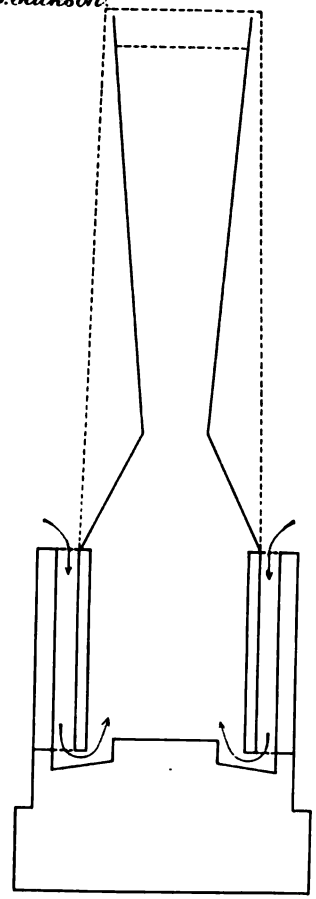
Mueseler-Harmegnies. No. 5.

Fig. 3.



Mueseler-Harmegnies. No. 6.

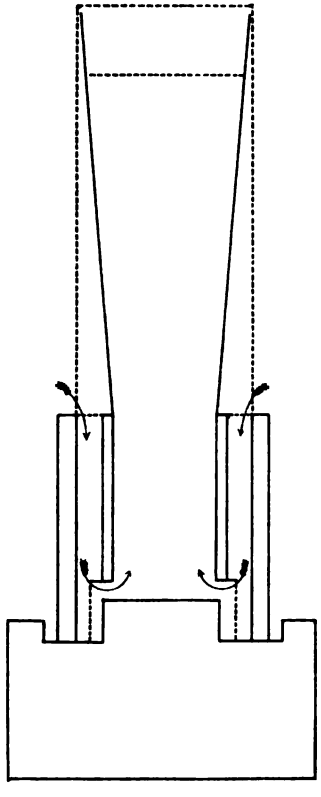
Fig. 4.



Morison.

To illustrate the Report of the Belgian Commission on Safety Lamps.—Translated by Mr C. G. Jackson.

Fig. 1.



MORISON - ARNOULD.

Engs No. E.I. of M. & M.E. 1879-80.

Fig. 2.

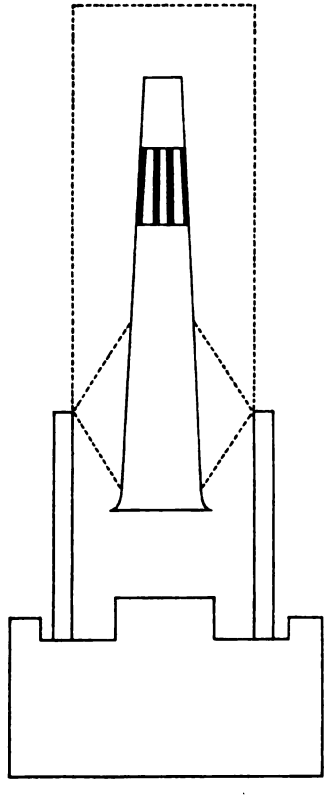
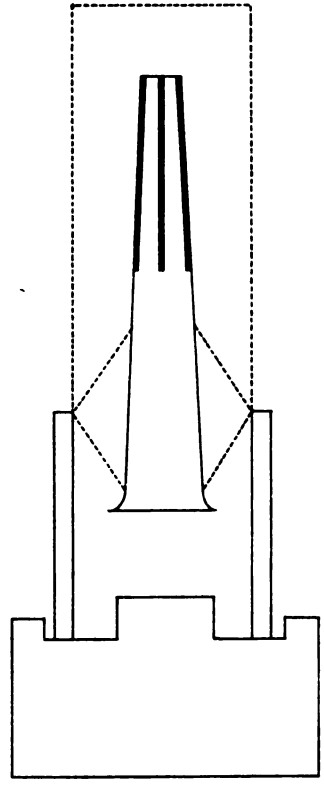
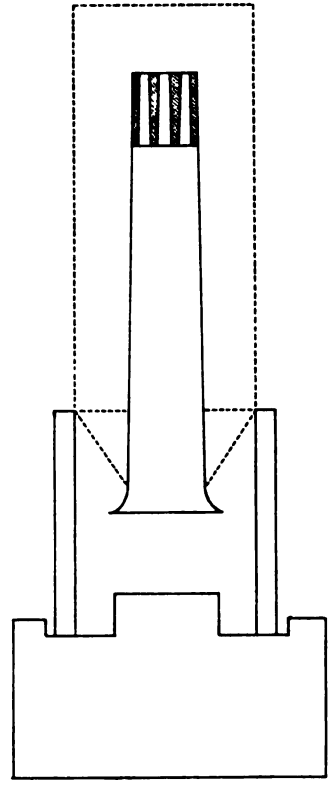


Fig. 3.



MUESELER - JOASSIN No. 2 WITH TUBULAR CHIMNEY.

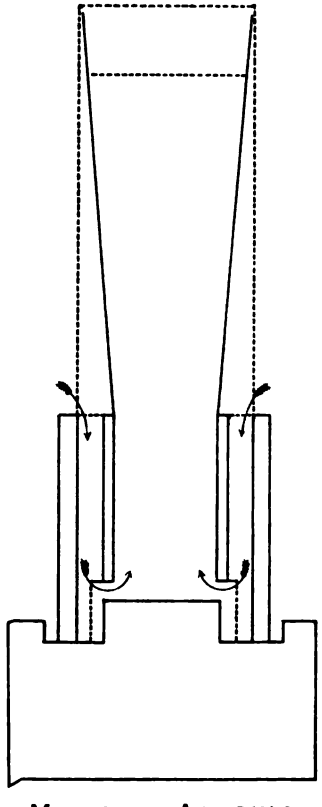
Fig. 4.



MUESELER - DEMANET.

Anst. Reid Newcastle

FIG. 1.



MORISON - ARNOULD.

FIG. 2.

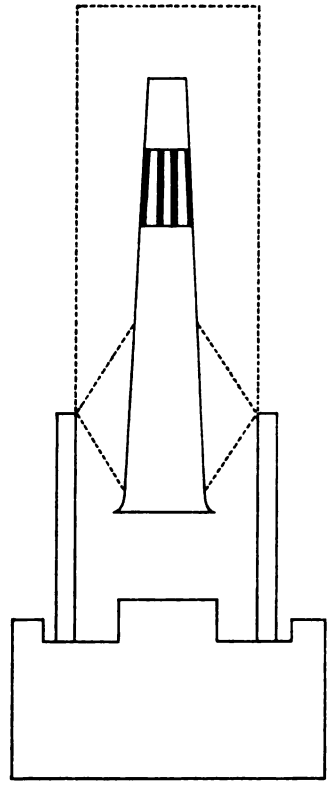
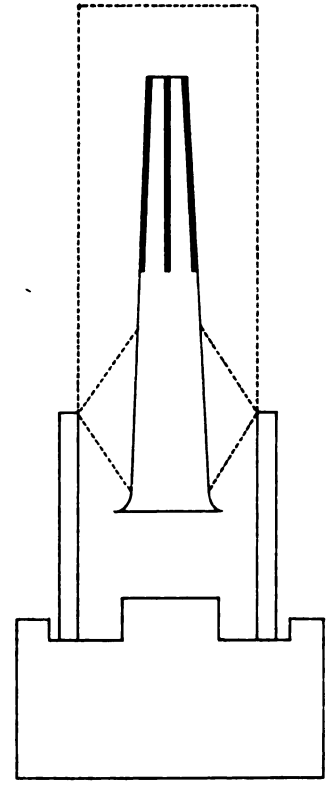
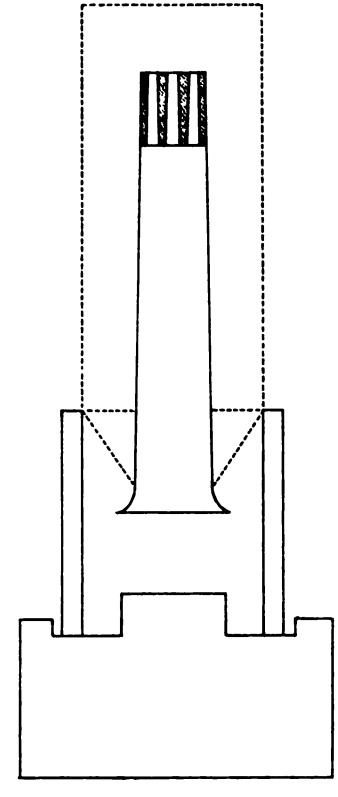


FIG. 3.



MUESELER - JOASSIN Nº 2 WITH TUBULAR CHIMNEY.

FIG. 4.

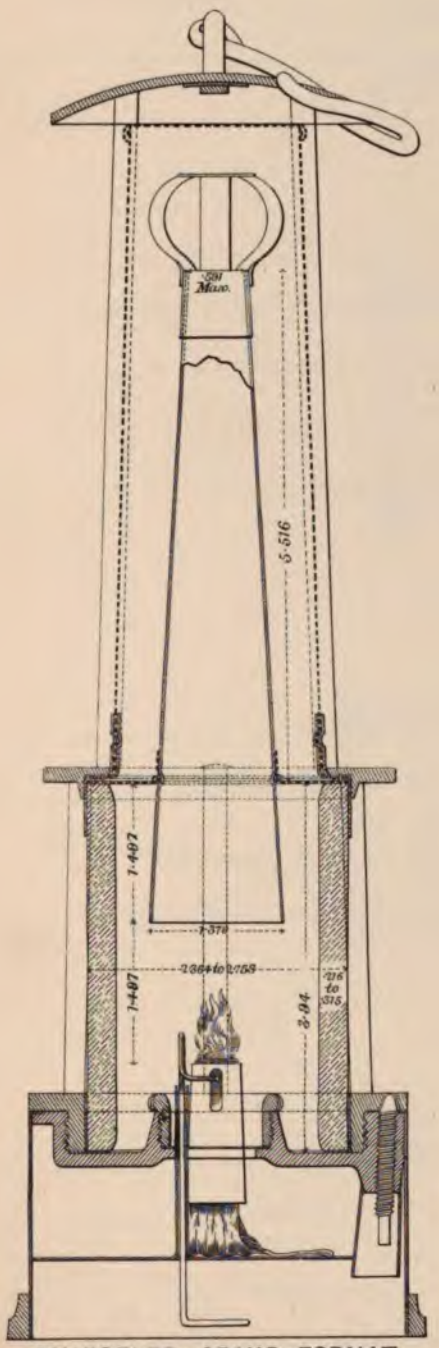


MUESELER - DEMANET.

Proceedings Nº E.I. of M. & M.E. 1879-80.

Anst. Reid Newcastle

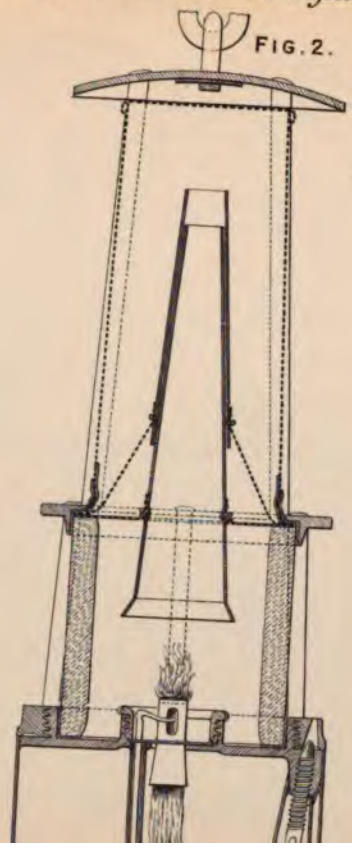
To illustrate "the Royal Decree on the lighting of Mines in Belgium" translated by Mr C. G. Jackson.

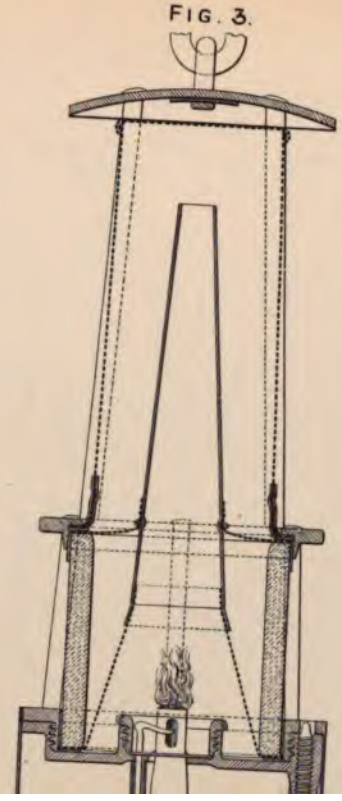


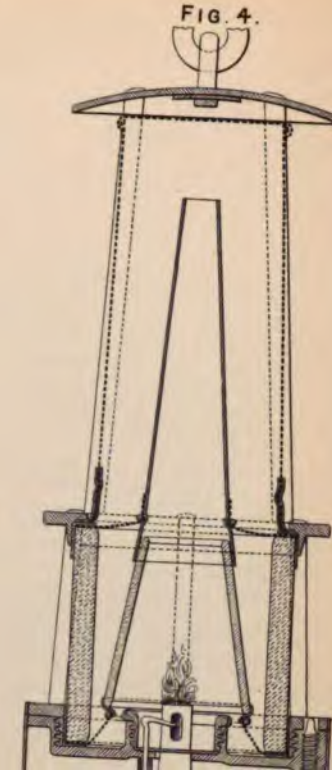
MUESELER-GRAND-FORMAT.

The Dimensions are given in inches and decimals.

To illustrate the Royal Decree on the Lighting of Mines in Belgium.—Translated by Mr C. G. Jackson.







To illustrate the Royal Decree on the Lighting of Mines in Belgium.—Translated by Mr C. G. Jackson.

FIG. 1.

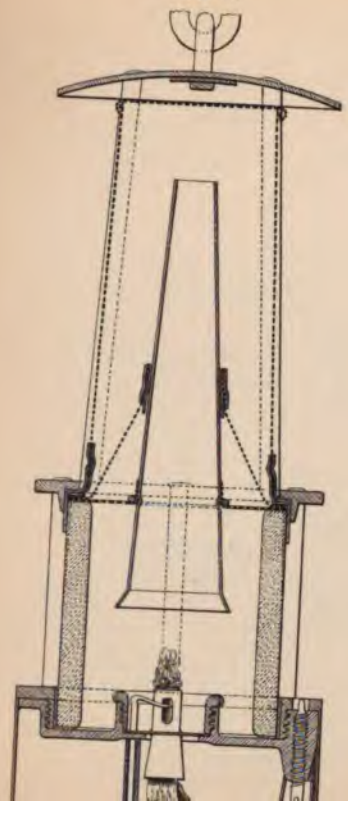


FIG. 2.

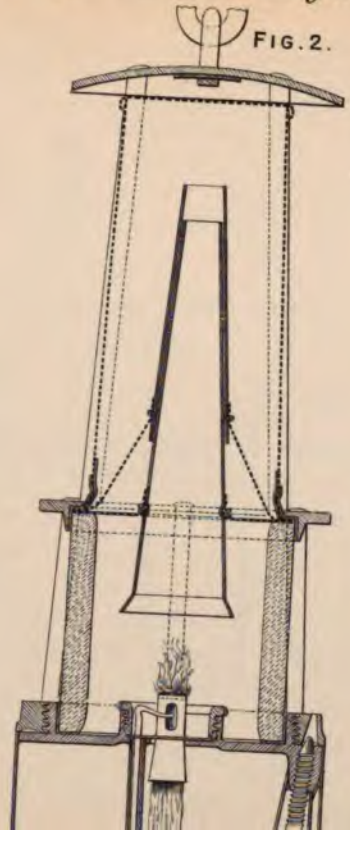


FIG. 3.

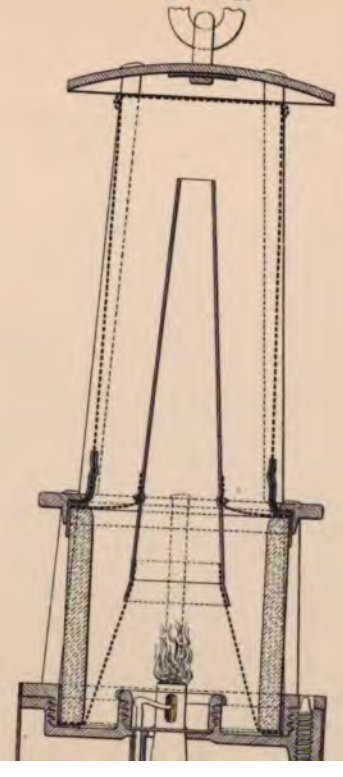


FIG. 4.

TABLE SHOWING THE DIMENSIONS AND DESCRIPTION OF THE MOST IMPORTANT PARTS IN THE LAMPS AUTHORISED BY THE ROYAL DECREE OF JUNE 17TH, 1876.

Lamps allowed to be used.	Glass Cylinder with metallic ring at both ends.			Internal Chimney. A conical sheet iron or copper tube with a funnel-shaped enlargement at its base.							Height of outer gauze.	Minimum diam. of gauze wire.	Minimum openings in a square inch.	Persons by whom or purpose for which the use of the lamp is authorized.	Remarks.
				Maximum Internal Dia.			Length of Chimney.								
	External Diam.	Thickness of Glass.	Max. height of glass including thickness of bottom ring.	At Top.	At Base.	At place of enlargement.	Above horizontal gauze.	Below horizon. gauze includ. enlargement.	Height of enlargement.	Distance from bottom of chimney to top of wick-holder.					
Typical Mueseler, Fig. 1, Plate XIX.	2·364	·216	2·442	·394	1·182	·985	3·546	1·063	·236	·866	4·294	·013	928	Workmen	Principally used in the Liége coal-field.
Practical limits allowed, Fig. 2, Plate XIX.	From 2·324 To 2·403	From ·197 To ·295	...	...	...	No enlargement.	3·467	·985	No enlargement.	·788	4·137	...	...	Workmen	Variations within these prescribed limits and absence of funnel-shaped enlargement at base of chimney occur principally in the Hainaut coal-field.
				·394	1·024		3·624	1·142		·945	4·452	·010	928		
Mueseler large type, Plate XX.	From 2·364 To 2·758	From ·216 To 3·152	3·937	·591	1·379	No enlargement.	*5·516	†1·497	No enlargement.	...	...	·013	928	Stationary lamps in or near shafts.	*If the mean of the internal diameter of the chimney at top and base is ·788, its length above the horizontal gauze must be at least 3·546. For every additional ·039, ·393 must be added to the height above the gauze. †The length of chimney below gauze must be at least equal to half the distance from gauze to wickholder.
Mueseler-Godin (Deputy's lamp), Fig. 3, Plate XIX.	Limits allowed as in typical lamp.											75	...	...	It possesses an internal glass cylinder supported on an ordinary stand, through which the air enters to the flame.

The dimensions are in inches.

nce of Mr. Sawyer, the SECRETARY then read that gentle-
"Notes on the Mueseler Lamp."

NOTES ON THE MUESELER LAMP.

By A. R. SAWYER.

Having had daily practical experience with the Mueseler lamp in the collieries in his district, the writer thought that a few remarks on its efficiency under ordinary circumstances would be useful to the members of this Institute.

This lamp was invented by a Belgian mining engineer, the late Mr. Mueseler, in 1840. It was examined by several Royal Commissions, which, after careful and prolonged trials, found and declared it to be in all respects superior to every other, and to present the greatest amount of security.

Thereupon an Act was passed in 1876 making the use of the Mueseler lamp compulsory throughout all coal mines.

The seams of North Staffordshire vary much in their inclination in different localities. The dip of the seams varies from the vertical to the horizontal. Many are very fiery. The "gas" which they produce is of very varying composition, judging from the odour and behaviour in the lamp. The presence of olefiant gas, a constituent of fire damp, is disputed by many, but the writer believes it to form more or less a part of the constitution of fire-damp in North Staffordshire.

Olefiant gas or ethylene (C_2H_4) differs from marsh gas in being a hydro-bicarbonate. Its specific gravity is ·9688; it is transparent and colourless, has a faint, sweetish, alliaceous odour, is very inflammable, and burns with a white luminous flame. It is inflammable at a mild red heat, and causes a much more powerful explosion than marsh gas.

Bishof found 16 per cent. of olefiant gas in fire damp of the lias formation, 6 per cent. in that of a "blower" at Wellesweiler, and 2 per cent. at Gerhard Colliery. He, therefore, defined fire damp as a mixture of marsh gas (CH_4), olefiant gas (C_2H_4), hydrogen, and carbonic anhydride (CO_2).

The fire damp in some of the seams invariably possesses the odour of olefiant gas. When elevated towards it the Mueseler lamp shows a

"cap," and then immediately goes out with a sharp noise, before the Davy shows any sign of gas. On a closer approach with the Davy the gas fires in it, and burns with a whitish flame. When this odour was less strong the writer has been able to fire the gas in the Mueseler lamp without its going out, by elevating it with care. In gas in which this odour is not perceptible, the Mueseler lamp on being elevated is first surmounted by a distinctly-shaped cylindrical blue flame, which loses itself in the chimney and then goes out. If carefully lowered, however, it will retain its flame.

The Mueseler is the most delicate lamp for detecting gas in the air currents. It shows a blue aureola or "cap" in places where the Davy shows none, thereby discovering a smaller percentage of gas than the latter. This is no doubt due to the steadiness of the flame produced by the regularity of the draught, but also to the flat wick, which is easily movable by means of a broad pricker. A good deal also depends on the quality of the oil, as with pure vegetable oil the flame can be lowered so as to remove the luminous envelope and leave the pale blue portion of the flame only. Mineral oils should never be taken underground; in Belgium it was found that they lessened the safety of the lamp, and are prohibited.

The writer has detected small quantities of gas in pot holes into which the Mueseler could only just be introduced, and where the Davy did not disclose any. The pot hole being high, the Davy could not be tilted for the purpose of bringing the flame to the gas; but in the Mueseler, owing to the current which is set up, the gas was brought to the flame.

Of all the lamps known the Mueseler is the one that gives the best light. The steadinesss of the flame remains unaltered by the velocity of the air in returns, where it can be lowered to a pale blue flame, when a Davy would be put out.

The sensitiveness of this lamp is often exaggerated. It requires a little more care in handling than a Davy, an obligation which is highly beneficial, for if tilted to one side it goes out, owing to the products of combustion mixing with the air, and thereby saves the glass.

The fact that the flame of an explosion travels towards the incoming air rather than along the return is well exemplified in the Mueseler lamp. If the outer gauze is removed, and the lamp placed in an explosive mixture, the explosion will not be communicated through the chimney; it will be checked by the horizontal gauze and go out. The writer found this out unexpectedly one day; having forgotten the outer gauze, he placed the lamp in gas, with the above result. The reason the flame travels apparently in the direction of greatest resistance is that it seeks

the air necessary for its existence. He has also seen the outer gauze removed, and the lamp exposed to a current of gas travelling 11 feet per second, without communicating the flame. The gas went on burning below the horizontal gauze for four minutes when the experiment was stopped. This shows that in ordinary cases, even if the outer gauze is injured, the lamp is still safe.

Complete extinction of the flame and gas takes place in currents not surpassing a velocity of 9·84 feet. If the velocity of the current increases, the flame goes out, but the gas goes on burning underneath the horizontal gauze for some time. Ignition of the gas within the outer gauze takes place if the draught by some reason or another is reversed just before its arrival. The writer never yet saw the gas fire within the outer gauze in the pit. The typical Mueseler lamp which he uses was made by Messrs. Mulkay Brothers, Outre-Meuse-Liège. It weighs 2¼ lbs., cost 4s. 0d., and gives the greatest satisfaction.

For the work of inspection a simple Davy should be used as well as the Mueseler, as for that purpose both have their uses. If firemen are equally provided, knowing the properties of each and using them accordingly, they may be considered safely and efficiently provided for their work. Several collieries in the district have adopted this plan, and the firemen all speak in favour of it.

In seams in which "blowers" are likely to be met with, or which are fiery, simple Davy lamps at the face are very questionable. The recent explosion at Leycett, which was due to the gas lighting at the only Davy lamp at the face, has shown this more strongly. All the other lamps were Teale's, an imitation of the Mueseler, which resembles it in going out in gas.

The following modifications of the Mueseler lamp, though not classed amongst those authorized in the Act, are, nevertheless, highly approved of. These are :—

1.—The Mueseler-Joassin lamp, in which the chimney is supported, as shown in Figs. 1 and 2, Plate XXI. It is particularly applicable in strong currents, where much dust prevails. The top end of the chimney should be ·334 inches in diameter.

2.—Another variety of the Mueseler-Godin lamp, Fig. 3, Plate XXI., having an internal gauze between the flame and the glass. This lamp and the next are highly to be recommended where there is a possibility of the glass getting broken, as they are doubly safe.

3.—The Mueseler-Arnould-Godin lamp, which differs from the Mueseler-Godin, Fig. 4, Plate XXI., in having the support of the internal glass cylinder surrounded with gauze. The top end of chimney should be from ·334 to ·354 inches in diameter.

In conclusion, it is advisable to lay great stress on the fact that the Mueseler, as well as all so-called safety lamps at present known, only offer a relative amount of security. They are, therefore, only auxiliaries necessary to complete a state of security mainly dependent on powerful ventilation and good disposition of workings.

Mr. Ashworth said, in reference to Mr. Sawyer's suggestion that a fireman should carry both a Mueseler and a Davy lamp, that one of the principal objects he had had in view in contriving his modification of the Davy was to place in the hands of a miner a lamp which would combine the advantages of the Davy with those of the Mueseler.

Mr. T. Lindsay Galloway had much pleasure in proposing a vote of thanks to Mr. Sawyer. He thought that the fact of that gentleman having himself used the Mueseler lamp underground for a considerable time gave an additional value to his paper, as there were other points besides the velocity-test which could be best ascertained by personal observation in the mine.

Mr. Cooke seconded the vote of thanks, which was unanimously carried.

Mr. James Ashworth then read a paper on "Improved Safety-Lamps of the Davy and Mueseler types":—

IMPROVED SAFETY-LAMPS OF THE DAVY AND MUESELER TYPES.

By JAMES ASHWORTH.

The importance of having a good and reliable safety-lamp, combined with a simple yet secure lock, has been for many years patent to all members of the mining community who have studied the subject; and it is not a little curious to note that until a few years ago persons having no practical knowledge of the working or requirements of a coal mine were those who pointed out the insecurity of the Davy and other safety-lamps, and who endeavoured to produce more reliable lamps; but now, thanks to the information disseminated by Mining Institutes, and this Institute in particular, many alterations have been made by their members to improve the construction of what may be termed our three standard lamps, viz., the Davy, the Stephenson, and the Clanny.

The lamps that have received the writer's greatest attention are the Davy and the Mueseler, and it is proposed to give a description of some suggested improvements in the construction of these lamps and the tests to which they have been submitted; and further, to place any part or all of these suggested improvements, none of which have been patented, at the service of any one who considers that they are worth adopting.

The first lamp is called the Ashworth and Woolrych Jack Davy lamp, Fig. 1, Plate XXII., and consists of an ordinary Davy lamp gauze of $1\frac{5}{8}$th inch in diameter by about 5 inches in height, the lower half of which is surrounded by a cylindrical glass shield; inside the cylindrical gauze is an arrangement similar to a Mueseler lamp, the metallic chimney being replaced by a cylindrical wire gauze $\frac{7}{8}$ths of an inch in diameter by $1\frac{3}{4}$ inches long, terminated by a thin copper or tin bell-mouthed cylinder of about one inch long, to which a horizontal gauze, levelled on its outer edge and in close contact with the outer cylindrical gauze, is attached; the whole of this arrangement is supported by two thin brass standards to maintain it at a proper height above the wick flame.

A gauze cap may be added to the outer cylindrical gauze where the lamp is liable to be exposed to ventilating currents moving at high velocities.

and in such a case the cap should be of sufficient length to enter the glass shield to the extent of half an inch for the reasons stated hereafter. The writer has used a lamp of this description but without the gauze cap and the thin metallic cylinder mentioned above, in the pit for some time, and found he could carry it with comfort in places where no Davy lamp, even when protected by a man's cap, could stand to give more than a miserable ray of light. The same lamp was tested by Mr. Smethurst and the writer at Brynn with an explosive mixture of air and pure fire damp from the Wigan six or nine feet mine, in a velocity commencing at 580 feet per minute, and in four-and-a-half minutes the glass shield was completely cracked but did not fall away; the velocity was then increased and decreased and the proportions of gas and air were varied, but the flame was not passed in fourteen minutes when the test was suspended. The outer gauze was made of iron wire, of 28 meshes to the inch, and the inside gauze of brass wire, of 36 meshes to the inch. It was found, on examining the lamp, that the nature of the brass wire was completely destroyed on the return side, and crumbled away when taken out for examination.

It appeared evident from the result of the above experiment that the parts of a safety-lamp, which have to sustain the effects of the combustion of explosive mixtures of fire damp and air, ought to be made as small as possible in their cubic contents, but to decide this point more conclusively other tests were made, the results of some of which, on the Davy type of safety lamp, with standard gauzes of 28 meshes to the inch, are given below :—

Diam. of Gauze in inches.	Velocity in feet per minute.	Time in secs.	REMARKS.
$\frac{7}{8}$	430	50	Exploded.
$1\frac{1}{2}$	420	5	"
$\frac{7}{8}$	600	$5\frac{1}{4}$	"
$1\frac{1}{2}$	600	4	"
$2\frac{3}{4}$	600	3	"
$3\frac{1}{2}$	600	$1\frac{1}{2}$	"

A Davy lamp with a $\frac{7}{8}$ths diameter of gauze of 36 meshes to the inch was not tested, although it is important that it should be, because Sir H. Davy says "that the ratio of the combustibility of the different gaseous matters is, to a certain extent, as the masses of the heated matter required to inflame them. Thus an iron wire of $\frac{1}{40}$th of an inch in diameter heated cherry red will not inflame olefiant gas, but it will inflame hydrogen gas; and a wire of $\frac{1}{8}$th of an inch in diameter heated to the same degree will inflame olefiant gas, but a wire of $\frac{1}{500}$th of an inch in diameter must be heated to whiteness to inflame hydrogen, though at a low heat it will inflame bi-phosphuretted hydrogen gas; but a wire of $\frac{1}{40}$th of an inch in

diameter, heated even to whiteness, will not inflame mixtures of fire damp and air. A tissue, which will not interrupt the flame of hydrogen when red hot, will still intercept that of olefiant gas; and a heated tissue, which would communicate explosion from a mixture of olefiant gas and air, will stop an explosion from a mixture of fire damp or carburetted-hydrogen."

It may therefore be concluded that the test of the Ashworth and Woolrych lamp fully bears out in practice what is stated above, and that the reason for the lamp holding out so long arose, in the first place, from the force of the current being broken by the outside gauze and glass cylinders; in the second place, from the small diameter and cubic contents of the inside gauze cylinder; and in the third place, from the resistance offered by the fine wire of the inside gauze cylinder.

It was thought by one gentleman that if a certain proportion of air were admitted into the lamp below the wick flame, as in the Stephenson lamp, beneficial results might be expected, and he had a lamp altered accordingly; but when tested with an explosive mixture of illuminating gas and air, moving at a velocity of 570 feet per minute, the result was not encouraging as the glass broke in 3 minutes 40 seconds, and in 7 seconds more the flame passed through the single gauze where the glass previously protected it. This result is to be attributed to the fact that the combustion of the gas in the lowest and weakest part of the lamp was greatly increased by the explosive mixture entering below the cylindrical glass shield, which was thereby exposed to a very high temperature.

After making some of the foregoing tests at Brynn, experiments were made on two of the Protector Lamp Company's Jack Davy lamps, Fig. 2, Plate XXII., both having cylindrical glass shields:—

Velocity = 565 feet per minute; exploded in 0 minute 19 seconds.
" = 600 " " " 1 " 28 "

These results led to an investigation into the cause of the difference in their staying powers, and experiments were then made with Davy lamps, in which the ordinary gauze cap was lengthened so that the cylindrical glass shield overlapped it to the extent of a quarter of an inch, with the following results:—

Velocity = 440 feet per minute; exploded in 22 seconds.
" = 580 " " " 14 "

The gauze caps were then lengthened so that the cylindrical glass shield overlapped it to the extent of half an inch, with the following results:—

Velocity = 500 feet per minute; did not explode in 3 minutes.
" = 600 " " " " 6⅓ "

The experiments made at Brynn proved most conclusively that a cylindrical glass shield is the only shield which adds to the safety of a Davy lamp, and then only when the gauze cap is made so long as to enter the shield to the extent of not less than half an inch; and the reason for this is, that the shield reduces the cubic contents of the lamp available for the combustion of an explosive mixture, and also because the part of the lamp above the glass shield is protected by a double thickness of gauze, which thus increases the depth of the apertures without adding to their area, and breaks the force of the current. In making this investigation the writer was materially assisted by Messrs. Walter Topping and U. E. Dickinson, the former being so well satisfied with the value of the tests that he altered all the Davy lamps under his charge accordingly.

Before closing these remarks on the Davy lamp it would be well to mention that the lowest velocity of an explosive mixture of fire damp and air, in which the flame passed the gauze at Brynn, was 420 feet per minute, and that an exposure of three minutes in a velocity of 400 feet did not pass it; but whilst making some experiments in North Staffordshire with illuminating gas, the flame passed the gauze in one case in seven seconds, and in another case in twenty seconds, in a velocity of 370 feet per minute, when the mixture consisted of Bambury coal dust licked up from the floor of the experimental tube by the velocity of the air, with the addition of one cubic foot of gas to every 56 cubic feet of air. The gas was measured by an ordinary gas meter, but as the result had the appearance of inaccuracy, further tests were made, out of which the following, by Mr. R. W. Oswald, assistant to E. W. Wilkinson. Esq., of the Harecastle Collieries, are quoted:—

The experimenting tube, which is 20 feet long, 12 inches deep, and 6 inches broad, was covered on the bottom to some extent with Bambury coal dust and 8 cubic feet per minute of illuminating gas was mixed with the air, so as to give a total velocity of 370 feet per minute, as measured by a Dickinson's anemometer; thus the proportion was 1 cubic foot of gas to 23·125 cubic feet of air, or 4·32 per cent. of gas. This mixture was further tested by Ansell's fire-damp indicator, to check the accuracy of the meter measurements, and, as will be seen by the detailed results, the meter and the indicator agree very nearly—

	Diameter of Gauze.	Shield.	Ansell's Indicator. Inches.	Per cent. of Gas.	Time. Seconds.	Remarks.
Davy lamp ...	1¼″	None.	0·07	6	11	Exploded.
Do. ...	1¼″	Down.	0·05	4½	7	Do.
Do. ...	1½″	None.	0·07	6	11	Do.
Do. ...	1½″	Do.	not tested.	—	11½	Do.
Do. ...	1½″	Do.	Do.	—	15	Do.
Do. ...	1½″	Do.	0·05	4½	10	Do.

What is experimentally the lowest velocity of this mixture, and also what is the lowest percentage of gas in such a mixture that will pass the flame through a Davy lamp, cannot at present be stated, as the experiments are not yet completed.

Mr. Galloway, in his recent experiments, proved that a mixture of *some* coal dusts (not all) and air, at the ordinary pressure and temperature, become inflammable when ·892 per cent. of fire damp is added, and it then burns with a red smoky flame. If a mixture of one part of fire damp to 56 parts of air, with the addition of Bambury coal dust, turns out on further experiments to be a mixture that will in a very few seconds pass flame through a Davy lamp in the low velocity of 370 feet per minute, the necessity for at once replacing it by a proper lamp, cannot be questioned.

The next lamp is of the Mueseler type, conforming as far as possible to the rules laid down by the Belgian Commission on Safety-lamps, and differing only in the details of, and additions to, its construction. In making alterations and tests on this type of lamp much labour might have been spared had a copy of the report of the Belgian Government Commission on Safety-lamps been obtained at an earlier date; however, the chief of the Belgian Mining Department, about eighteen months ago, favoured the writer with printed copies of the report and decree (in French), which have been translated by Mr. C. G. Jackson, Wigan, and inserted in the Transactions. The details of each series of experiments have been somewhat abridged, but any member who wishes can obtain these details in full by referring to the Belgian Safety-lamp Report of the 20th of January, 1868, now in the library of this Institute.

The construction of the lamp is as follows, Figs. 1 to 6, Plate XXIII.:—Cylindrical gauze of 32 meshes to the inch, with a bevelled copper or iron ring rivetted to its bottom edge, which ensures a better and more secure fit than the ordinary English mode of simply bevelling the gauze; this ring also clips the top part of the cylindrical glass. The ordinary cylindrical glass is replaced by a glass in the form of a truncated cone, which gives increased strength with less liability to breakage,—

Firstly—Because a bevelled face is presented in almost every direction to resist accidental blows.

Secondly—Less risk of fracture from variations of temperature.

Thirdly—When fractured, less liability to fall to pieces.

Fourthly—The cubic contents are reduced almost to a minimum.

The horizontal gauze is of the ordinary construction, but it is protected from currents moving at high velocities and from dust by a thin metallic shield, which is crimped at its top edge with one-half of the points turned

inwards to touch the chimney, thus leaving only a limited space for the admission of air, and at the same time forming a further support to the chimney; it also serves the object of bringing the intake air into close contact with the hottest part of the chimney, and supplying it to the flame at a high temperature, thereby materially assisting the illuminating power of the flame.

The chimney is made up of two parts, the bottom one being of glass, with the object of utilizing the rays of light which are lost in the ordinary metallic chimney, the top one being of the ordinary construction. The increased light obtained by adopting this form of chimney may be considered by some to be more than counterbalanced by the addition of two more loose parts to the lamp, and a little increased first cost, and therefore it need not be considered as a necessary part of the lamp.

This appendage to the chimney, called the chimney-pot, is designed for use where the lamp is exposed to very high velocities, to prevent any vacillation of the flame or reversal of the draught in the chimney, and these objects it fulfils effectually.

The oil reservoir is of the ordinary construction, but is completely filled with sponge, to absorb the gas oil; and the opening by which the reservoir is filled with oil, is secured by a screw plug to prevent any of the gas escaping. The lock consists of a round bar X, as shown in the section through E F, with a groove cut in it about midway of its length (see the section through C D, Fig. 6) in which a loose ring Z is placed, having the same external diameter as the locking bar; and the end of the bar W, where it touches the wick tube, is reduced in diameter. The loose piece G is hexagonal at the lower part and cylindrical at the upper part G′, where it is reduced in diameter. When the upper parts of the lamp, have been put together, the part H screwed up to secure the glass, etc., and the part G put into its position round the wick tube, the lamp is ready for lighting. When lighted and screwed together, the locking bar is pushed into its place, and the loose ring falls down as soon as it passes through the part H, Fig. 6, and effectually prevents the bar being withdrawn, the lamp being finally locked by a lead rivet or a padlock through the hole K. The lamp being thus locked, the wick flame can be reduced by unscrewing the oil reservoir about three-eighths of an inch, that is, until the collar on the wick tube I comes in contact with the end W of the locking bar X. Supposing that the lamp is tampered with, and the lead rivet or padlock is removed out of the hole K, the locking bar may be pulled out about three-sixteenths of an inch, that is until the loose ring comes in contact with the part H, and this will enable the

oil reservoir to be completely unscrewed from the rest of the lamp; but as the part G will still remain in position, the light is extinguished by asphyxia whilst passing through the part G.

Gas-oil has been adopted, because—firstly, ordinary burning oil will not pass up the long wick tube fast enough to supply the flame; secondly, because it is infinitely cleaner than any other oil; thirdly, the light is superior, and causes no soot; and fourthly, because smaller proportions of fire damp can be more easily detected than when colza or rape oil is used.

Considerable objections have been raised at various times against the adoption of this class of oil for use in safety-lamps, but the writer is confident that practical experience will show that its advantages surmount all its disadvantages, as, in addition to the above-named points of superiority, it is easily extinguished by concussion, so much so that if the glass is broken or fractured by a blow, the light is at once put out.

The Belgian Government Commission reported unfavourably on the use of petroleum in safety-lamps, but the application of the two oils is totally different; for in the case of petroleum a highly inflammable oil is used, which can be spilt on the gauze or other parts of the lamp, whereas in this case the sponge absorbs the oil, and there is none to spill; and again, when the latter is used, the flame cannot possibly pass down the wick tube or otherwise into the reservoir. The only care really needed to prevent an accident where this oil is used is in the filling of the lamps, for, once properly filled and closed, no accident can occur.

The ordinary oil lamp, Fig. 3, Plate XXII., is of the Mueseler type, and called in North Wales the New British lamp. The chimney pot, the horizontal gauze shield, and a conical glass have been added to test the value of these additions to a lamp which does not conform to the dimensions ordered by the Belgian Government, especially in the diameter and proportions of the chimney.

The attention of the writer was first called to the importance of reducing the cubic contents of the glass cylinder of the Mueseler lamp when testing a small oil Mueseler, having a glass cylinder of 1·576 inches internal diameter against the large oil Mueseler (Fig. 3), the internal diameter of the glass cylinder of which was 1·970 inches, the result being that the pressure of gas could be discovered in places where no trace could be found with the Mueseler, Fig. 3.

The lamps, Plate XXIII. and Fig. 3, Plate XXII., were tested in their complete forms, in explosive mixtures of illuminating gas and air, at velocities ranging up to 1,000 feet per minute, but without succeeding in igniting the gas under the horizontal gauze or in obtaining an explo-

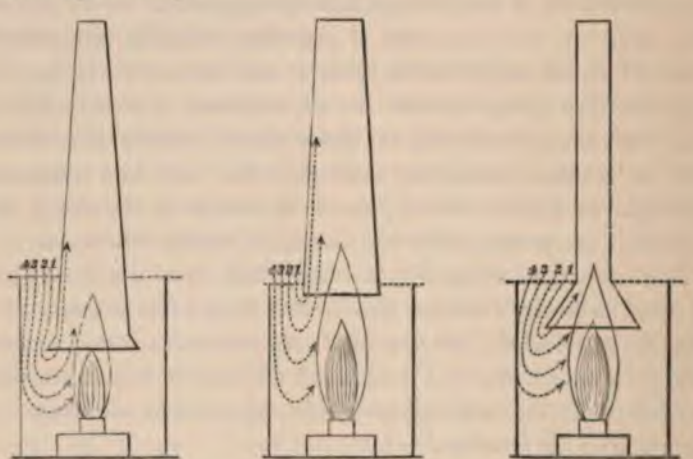
sion. The high temperature at which the mixture is supplied to the flame appears to have the greatest influence on the rapid and quiet extinction of the flame.

The writer is indebted to D. P. Morison, Esq., for the following details of his tests on these lamps, made at Pelton on the 13th November, 1879:—

Oil lamp	...Velocity = 13½ ft. per sec.;	went out in 8 secs.
Gas-oil lamp ...	„ = 13½ „ ;	continued burning over wick-flame until glass cap was nearly red hot.

The lamp appears to stand the test of the gas well up to 19½ ft. per second.

To overcome the difficulties that arise from rigidly carrying out the Belgian rule for the proportions of Mueseler chimneys where large wicks are used, the adoption of the form of chimney shown in the sketch, Fig. 4, Plate XXII., is suggested, which would enable a shorter chimney to be used with equal safety.



Supposing that the dotted lines, No. 1, 2, 3, 4, in woodcuts G, H, and J, represent four currents of an atmosphere not actually explosive but which contains sufficient gas to show a perceptible blue cap, Nos. 1 and 2 would be a considerable distance up the chimney in G, and particularly in H before Nos. 3 and 4 could come into contact with the wick flame and elongate it (as shown by the lines round the flame), and when the proportion of gas had increased sufficiently to explode, the current up the chimney would be reversed and the carbonic acid gas contained in the chimney should extinguish the flame, but as the No. 1 and 2 currents have already passed up the chimney without being converted into carbonic acid

gas, this result would not be fully accomplished; and on the influx of another volume of the explosive mixture, the second explosion would pass up the chimneys of G and H into the large gauze cylinder without hindrance, and in the course of a very few seconds cause an explosion of the outer atmosphere.

In the case of the J type of lamp, a separate stratum of gas could not exist past the point where the bevelled part joins the straight part of the chimney; and as a larger percentage of the intake air impinges on the flame than in the G and H types, the flame would elongate with a blue cap much sooner, and consequently fill the chimney with a sufficient quantity of carbonic acid gas to extinguish the flame when the actual explosion took place, and thus preclude the chance of a second explosion passing up the chimney.

In Fig. 5, Plate XXII., is a suggested alteration in the form of the Stephenson glass cylinder and cap, with a view—first, to reduce the cubic contents of the glass cylinder; second, to prevent the flame passing up to the top of the lamp; third, to lessen the cost of the glasses; and fourth, to reduce the breakages.

Up to this date there has been no opportunity to test the value of either E, F, or J suggestions.

In concluding this paper the writer wishes to call attention to the great want of standard types of each of the various safety-lamps in use in Great Britain; and to exemplify this he will take the proportions of the Mueseler lamp chimney, and compare the relation which the diameter of the top of the chimney bears to its length:—

Belgian standard Mueseler	·394 in. at the top, by	4·698 in. high.		
Gas-oil (Plate XXIII.)	·394	„	4·698	„
Ordinary oil (Plate XXII., Fig. 3)...	·413	„	4·000	
„ (H) „ tested by Mr. Williamson, at Cannock ...	·630	„	3·743	„

Compare the two extremes. The Belgian lamp has a maximum diameter of ·394 in. by 4·698 in. in height, and, following the same rule, Mr. Williamson's chimney should have been 6·067 in. in height, whereas it was only 3·743 in., and therefore 2·324 in. too short; and it is not surprising to find that it passed the flame in a 10 ft. velocity in 14 seconds, and in a 20 ft. velocity in 11 seconds.

This example is of itself sufficient to show that a standard is urgently required; but when it is found that the chimney and horizontal gauze are often removed from the large Mueseler, and the lamp taken into a fiery mine as a Clanny lamp, its importance is still further exemplified.

Our Government, with a due appreciation of free trade, will not attempt to make the use of any particular lamp compulsory, but the time has now arrived when the thinking part of the mining community have a right to demand that safety-lamps shall be made in accordance with standard types only, and that the making of them otherwise shall be an offence against the laws of this country, and punishable by such fines or otherwise as will secure their due observance.

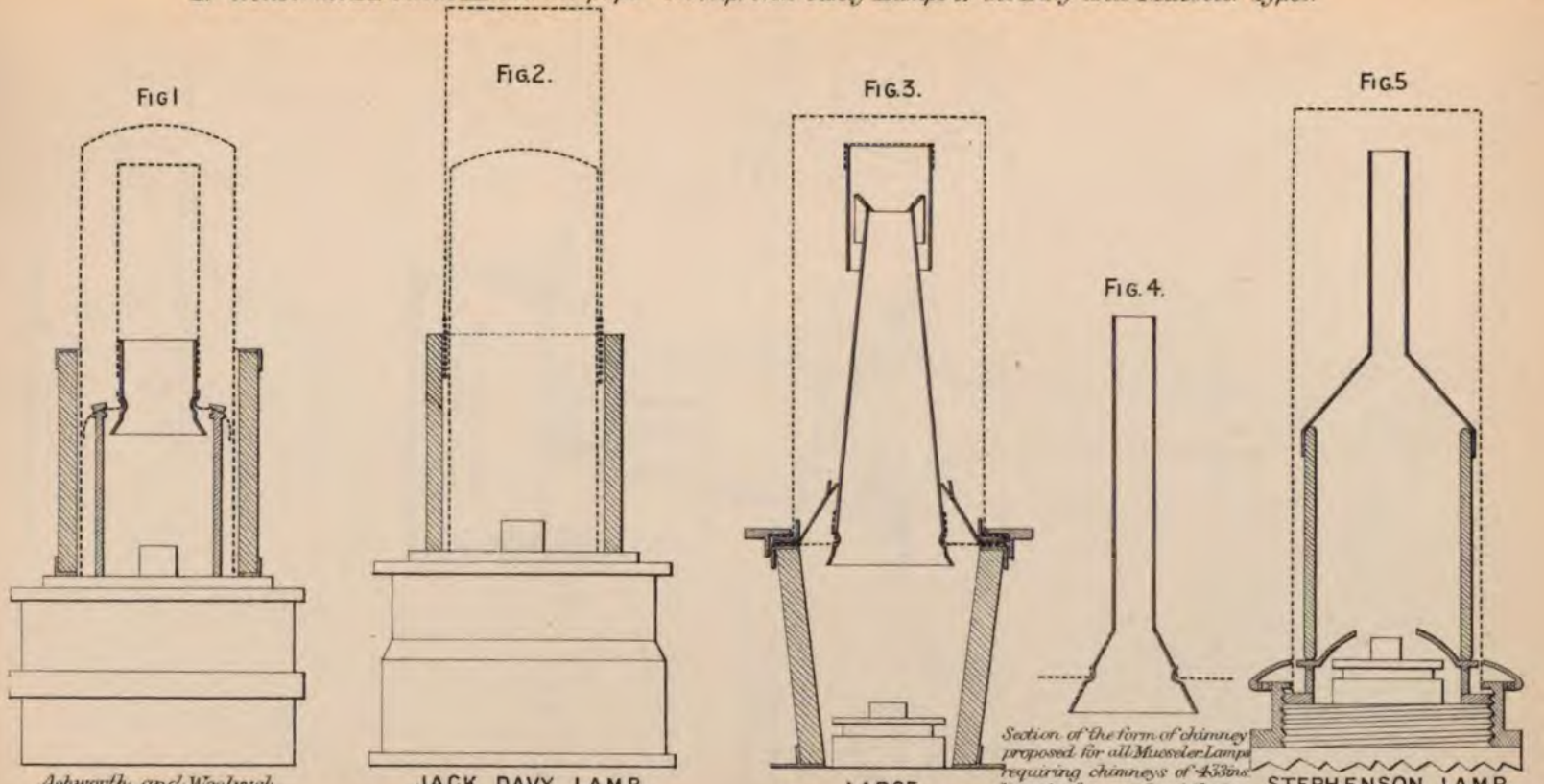
Mr. J. H. MERIVALE stated, with reference to the Mueseler lamp, that it was always extinguished when slightly tilted on one side, and he knew that in Belgium the miners frequently left the chimneys of their lamps at bank for this reason. He would be glad to know if there were any improved modifications of that lamp which would overcome that objection.

Mr. D. P. MORISON stated, that he had been requested to take charge of the first experiments made with the improved Mueseler lamps in this country at Pelton in 1868, in company with Mr. Arnould, who had brought with him some of the lamps of the Government type, the use of which is now made compulsory in all the fiery mines of Belgium. He need hardly remind the members that the Mueseler lamp was not found to possess any uncommon merit. Mr. Arnould then contrived a lamp called the Mueseler-Arnould lamp, which answered very well, and would not explode unless exposed to a strong current in an exceptional way. With regard to the lamp Mr. Ashworth had introduced to their notice to-day, he had seen it tested at Pelton, where it certainly could not be exploded, and he thought that after having been simplified by some practical lamp-maker it would prove a very valuable and efficient lamp. When the discussion was renewed he hoped to be in a position to furnish them with further details on the lamps alluded to as well as on safety-lamps in general.

The PRESIDENT said, that with regard to safety-lamps in general, he had an idea, founded on his own experience, that a Davy lamp was the safest; he certainly had never known it explode in practical use.

Mr. ASHWORTH thought that Mr. Greenwell would modify his opinion when he reminded him that the September explosion at the Leycett Colliery was proved at the inquest to be attributable to a Davy lamp passing the flame; if any doubt rested on this case he could quote another and better authenticated example of a Davy lamp passing the flame given by Mr. Dickinson at a meeting of the Geological Society at Manchester. It was a

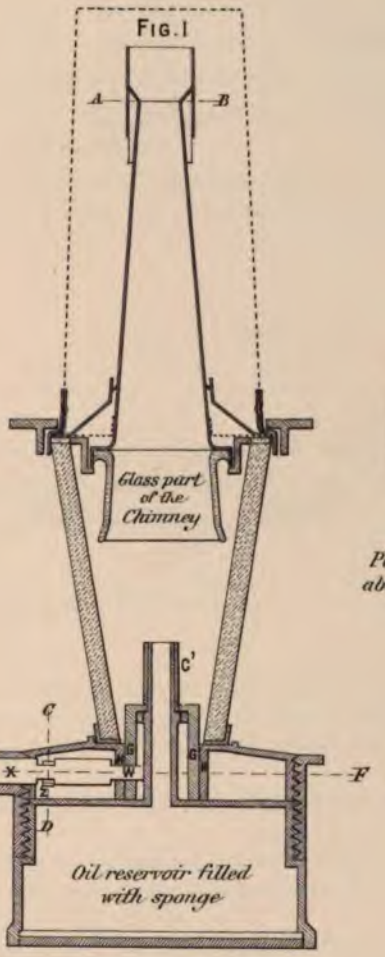
To illustrate Mr. James Ashworth's paper "On improved Safety Lamps of the Davy and Mueseler Types."



Proceedings No. E. I. of M. & M.E. 1879-80.

To illustrate Mr. James Ashworth's paper "On Improved Safety-lamps of the Davy and Mueseler Types."

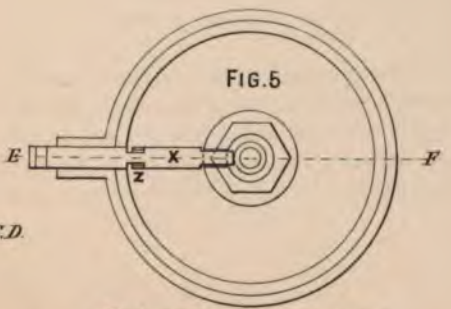
Section through A.B.



Plan of the Brass ring which carries the Glass part of the Chimney

Plan of the Copper shield above the Horizontal gauze

Cross Section through C.D.



Horizontal Section through E.F.

case where two men were working in an airway in a pit in the neighbourhood of Ashton-under-Lyne when an outburst of gas occurred and met the men, and in spite of all their efforts the flame passed the Davy lamps; both men were got out alive, but one died shortly afterwards. With regard to the reversal of the current in the Mueseler chimney, and the occasional passage of the flame through the horizontal gauze, the shield and chimney pot had been added in his lamps expressly to overcome these occurrences, and he was glad to find that experiments had proved that neither of the altered Mueseler lamps had passed flame.

On the motion of the PRESIDENT, seconded by Mr. D. P. MORISON, a vote of thanks was passed to Mr. Ashworth, and the further discussion was postponed.

The SECRETARY then stated that a few months ago he had sent some lamps to Mr. W. Armstrong to be experimented upon, amongst others a multitubular one invented by a Mr. Howat, a drawing of which is given in Plate XXIV.

Mr. Armstrong's report is as follows :—

June 18th, 1879.

Two velocities were obtained in the trial box of 13½ and 17½ feet per second. Coal gas was mixed off in such proportions as to blow up the Davys in three and five seconds respectively; and the other lamps were subjected to the same mixture and the same current.

The Belgian lamp (hewer) in every case was extinguished in three seconds; it could not be blown up.

The Belgian Deputy lamp was extinguished in three seconds, and two seconds in the weaker current of 13½ feet per second. In a former trial it was blown up, but this result could never afterwards be attained.

The Multitubular lamp, Plate XXIV., is very petted. It is a safe lamp, and is self-extinguishing, but the air tubes are apt to get slightly stopped by soot, and the cap is simply screwed on. In pillar working, where the air current is very weak, the lamp will not burn; and again, in high currents it is unsatisfactory and is affected by small movements.

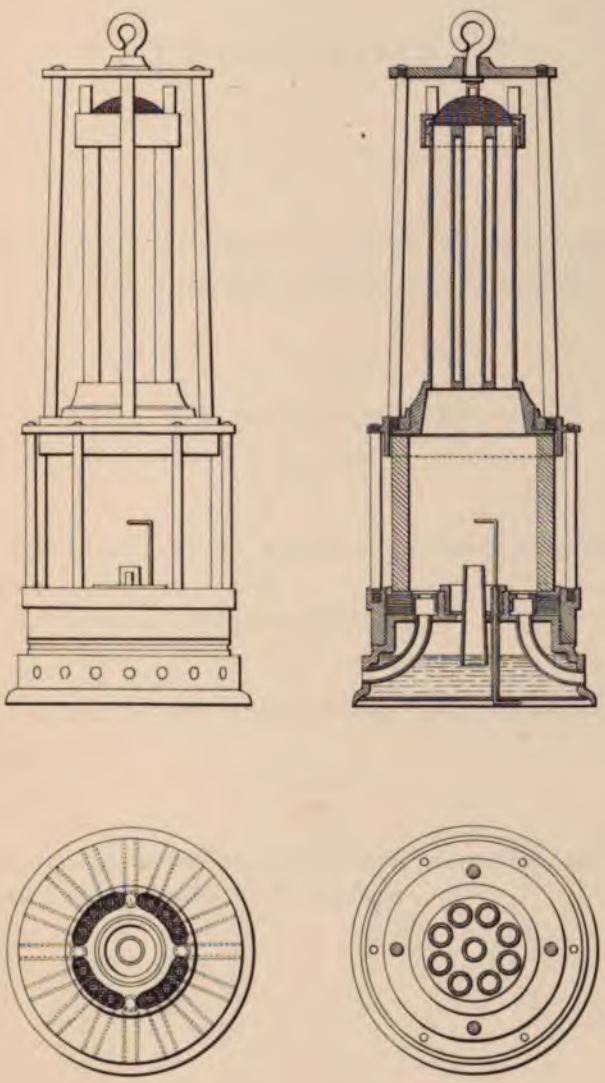
The Williamson lamp is safe and was extinguished in two seconds in the 17½ feet per second current, and all attempts to blow it up were ineffectual.

All these lamps have been in the hands of the overmen, the deputies, and the ordinary hewer. Williamson's has the preference, and the Tube lamp is disliked by all. There is little or no objection to the others as to working lamps.

It is not intended here to refer to the construction of the lamps, whether one or two glass cylinders, or any other detail, is advisable or not, but merely to their popularity with the classes who have used them, and to their standing the trials to blow them up.

Mr. A. L. STEAVENSON then stated that he hoped to be able to introduce Professor Forbes, of Glasgow, to the next meeting to exhibit a new mode of ascertaining the presence of very small quantities of gas in the atmosphere.

MULTITUBULAR LAMP INVENTED BY Mr. HOWAT.



PROCEEDINGS.

GENERAL MEETING, SATURDAY, MARCH 6TH, 1880, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

E. F. BOYD, ESQ., IN THE CHAIR.

THE SECRETARY read the minutes of the last Meeting and reported the proceedings of the Council.

The following gentleman was elected:—

STUDENT—

Mr. CHARLES JAMES MURTON, Jesmond Villas, Newcastle-on-Tyne.

The SECRETARY then read the following paper, "On Lührig's Method of Coal Washing," by Mr. E. P. Rathbone.

LÜHRIG'S METHOD OF COAL WASHING.

THE writer having recently visited, with his friend Mr. Lawrence, the coal-field of Zuickau, in Saxony, was much struck by the excellent methods of coal washing which he saw there, and thinking that a description of the same might be of some interest to the members of this Institute to which he has the honour to belong, prepared a paper, which, with the help of his friend, he is now enabled to place before them.

The information in this paper was collected from a number of sources, but principally from a paper written on the subject by Mr. Kreischer, Professor of Mining at the Royal Mining School, Freiberg.

The methods of ore dressing which were formerly exclusively applied to ore mining have latterly been applied to other substances, especially to coal, which till quite recently was seldom dressed in any other way than by hand labour, which could only deal with the simple separation of coal from dirt. Coal dressing by the wet way was scarcely ever employed formerly, and indeed was then hardly necessary, as the production of large coal perfectly sufficed for the demand and gave the desired profits, so that the small was either thrown away or left in the mine as useless, and any special hand separation was only employed in mines where the coal was particularly dirty. But as demand and wages increased, and the requisitions of other branches of industry, especially that of iron smelting, caused the prices of coal to rise according to their purity, heating power, and other qualities, the coal industry was forced, not only to supply a better article than before, but also to value that which had previously been despised. The demand for greater purity in the coal showed itself principally in the development of the coke trade, and the larger requirements of the iron industry. The value of the poorer qualities of coal became more evident as the prices rose, and this the expansion of the coke trade proved more than anything else, as it was soon found that small coal, or smudge, made larger and more compact coke than large coal, which by itself always commanded a ready sale. Mines which were only working clean seams were of course little affected by this change, but less favourable circumstances in other mines obliged the owners to make every effort in order to

compete satisfactorily with their neighbours. Thus a first-rate field for the development of coal washing immediately sprung up at such mines, and it is consequently amongst them that the best methods of coal washing in practice are found. The difficulties to overcome are not so great as in ore dressing as the specific gravity of the two substances to be washed (*i.e.*, 1·3 for coal and 2·3 for dirt) give a most favourable proportion for the sieves of the jiggers; but it is found necessary to construct slightly different jiggers to those used in ore dressing, because of the large amount of material treated by them at one time, which necessitates a continual action, working by hand proving insufficient. Good results are not so easily obtained with the fine coal, namely, that ranging in size from ·236 inches; the system of using depositing beds and jigging frames as in ore dressing, only proved partly practicable for this purpose; for, although it was easy enough to obtain good results with depositing beds, jigging frames proved to be quite useless. Most systems of coal washing are therefore reduced to the performance of three operations, namely, 1st, Classification of the coarser sizes by screens, etc.; 2nd, Washing the same on jiggers; and, 3rd, Concentration of the fine mud in depositing beds; this produced a reduction of the percentage of ash in the small only, as particles of dirt under ·0394 inches were deposited with the coal. The principal failing in all these systems was, not that they were not good enough as far as they went, but that they did not go far enough, that is, the degree of cleanliness was not carried to a fine enough result. Improvements in this direction had therefore to be studied, and they were first carried out in a decisive manner by Mr. Lührig, a renowned ore dressing engineer. He accomplished his purpose by the adoption of specially constructed Rittinger Spitz Kästen, better known to English engineers perhaps as Rittinger's grading boxes, and the well known Hartz-jigging machines. M. Lührig did not himself invent any of the machinery in connection with his washing establishment, except certain scoop wheels attached to the jiggers described hereafter, praise being due to him solely for his originality of ideas, in adopting certain machines, with a suitable dressing plan, which by a long series of experiments he proved were best suited to the washing of coal; and it is this system which is now very generally adopted all over Germany, is fast making its way into France and Belgium, and will not be long before it makes its way into England, where with a few alterations it would be well suited to many collieries where the coal is dirty and a large amount of small is made. In the following description of this system, for the sake of convenience, the principal machines in connection with the plant will be first described in

detail, and then a full description of the combined plant and method of washing in general will be given, finishing with a few statistics as to cost, etc.

LÜHRIG'S PATENT CONTINUAL ACTION COARSE JIGGERS.

After a large number of observations and experiments, a medium size of these machines, which according to the degree of impurity and coarseness of the coal, washed from 150 to 200 cwts. of coal per hour, was found to give favourable results. With coal giving on assay 24 per cent. of impurity, they washed about 150 cwts. per hour, but on the percentage of impurity being reduced to 10 per cent. they washed 200 cwts. The following is a description of this medium-sized jigger:—The jigger box is held together by uprights of $2\frac{1}{2}$ inches square, and is about 9 feet 10 inches long, 3 feet $1\frac{1}{2}$ inches broad, and 4 feet 7 inches deep. The top part of the box is divided by a partition board *a*, Plate XXV, Figs. 1, 2, 3, and 4, which reaches to a depth of 2 feet $2\frac{3}{4}$ inches. This partition therefore divides the whole box into two parts, namely, one for the piston and the other for the sieve. The inside of the box is lined with wood $1\frac{1}{2}$ inches thick, so that there still remains an area of about 4 feet 6 inches × 2 feet 10 inches = 12·75 square feet for piston and sieve. The bottom, *b*, the lowest point of which should be exactly under the middle of the partition, is curved so as to cause, through the up and down motion of the piston *c*, a flow of water favourable to the sorting and delivery of the coal. The mesh of the sieve *d* depends on the size of the grain washed; that is, for example, $\frac{1}{2}$ inch for large size coal (cobbles) and $\frac{1}{4}$ inch for nuts or smalls. The sieve is fixed so as to be 19 inches below the top edge of the front side of the box, and 21 inches below the top edge of the partition, so that there is an inclination of 1 in 24 from the front to the back. This is done in order the better to retain the heavier pieces of dirt. Under the sieve are fixed five wooden bars *e*, to resist the strain on it. The feeding takes place by means of a trough, which is fixed on to the back side of the jigger box, so that it just comes over the deepest part of the sieve. The coal being lifted by the upward pressure of the water is carried out through the slit *f*, which extends across the whole front side of the jigger box, while the dirt sinking on the sieve gradually falls out through the opening *g*, (4 inches × 10 inches), which is fixed 2 inches above the level of the sieve, into the dirt trough *h*. The slide or valve *i*, which regulates the size of the opening, is acted on by a lever *k* and a connecting rod *l*, and is kept in its place by the slot *m*. But in order to prevent the coal when entering from passing through this slit, a shield or screen *n* is fixed over the same,

which can be regulated by screws, but as a rule when once it has been adjusted it does not require to be again altered. The dirt passing through the opening *g*, is caught up by the scoop-wheel *o*, and delivered by it on to the funnel *p*, over which it falls into the spout *q*, from the bottom of which it is removed in a manner to be described hereafter. The separate delivery of the dirt from each jigger by this scoop-wheel, possesses one great advantage, namely, there is always a safe control over the amount (*i.e.*, the quantity and quality) of work which each jigger is doing. In order to watch this control a sort of spoon is used by which samples can be brought up from time to time, thus it can immediately be detected if any one machine is delivering coal with dirt, or otherwise neglecting its duty. Each separate scoop *r* is so pierced with holes that the water can easily drain off. The motion of these scoop-wheels is transmitted through bands from the principal working axis *s*, the axis receiving its motion from the pulley-wheel *t*. The motion thus transferred to the principal axis is again transferred through the slot *u* with a slide block *v* to the axis *w*, and from there by two forked piston rods *x* to the piston, which is therefore fixed at four different points, whereby a regular and steady motion is ensured to the course of the piston. In order to replace the loss of water caused by the continual outflow, a water pipe *y* is connected to each machine, the supply for which is regulated by the valve *z*. The coarse sizing jiggers make 60 strokes per minute, those washing the next largest or middle size 65, and all the rest 70. The scoop-wheel makes ten revolutions per minute. Lastly, the very finely divided refuse which sinks through the mesh of the sieve is collected at the bottom of the jigger box, and is from time to time cleared out by means of raising the valve *b'* by the lever *a'*, and is thus allowed to flow out into a trough in connection. All other details can be clearly seen in the drawings.

LÜHRIG'S FINE COAL JIGGERS.

This jigger is on the whole similar to the one known amongst ore dressers, as the continual fine grained jigger, and is shown in Plate XXVI., Figs. 1, and 2. The inside of the box is lined as before with wood, and has a length of 8 feet 3 inches at the top, and a breadth of 3 feet 3 inches. At the bottom the back has a length of about 2 feet 6 inches, but increases in length on the front side to 4 feet 4 inches, the bottom of each jigger being thus pointed. The partition *a* divides the whole into two separate jigger boxes, and the partition *a'* divides this again into two equal parts, so that there are two pistons and two sieves in each jigger box. This partition extends to a depth of 19 inches, the area taken up by the piston

and sieve being about $5\frac{1}{4}$ square feet. The sieve *b* is fixed $11\frac{3}{4}$ inches below the top edge of the jigger box, and is strengthened as before by wooden bars *c*. The piston *d* is constructed out of two massive pieces of wood, has a thickness of $3\frac{1}{8}$ inches, and is fixed as shown to the piston rods *e*, which derive their motion from two eccentrics fixed on to the axis *f*. The length of the stroke varies according to the size of the grain treated, from $\frac{1}{4}$ to $1\frac{1}{2}$ inches. The axis is rotated by means of the pulley-wheel *g*, the number of strokes varying between 130 to 175 per minute. A layer of 3 inches of feldspar *x* is placed on the top of the sieve.* The stream of coal which has previously been subjected to a separation in the Spitz Kästen, or grading boxes, Plate XXVII., Figs. 1, 2, and 3, flows on to the first sieve through the entrance *h*, and is there immediately acted on as follows:—The water in the jigger box below the sieve is subjected to short and quickly-repeated blows of the piston; the lighter particles of coal are thus kept continually in suspension, and are therefore washed by the force of the entering stream into the next sieve compartment, while the heavier particles of dirt sink and pass through this bed of feldspar and through the sieve into the pointed-formed part of the jigger box below. From here it is led off by a trough in connection with it through an opening *i* with a lid *k*. The second jigger compartment does the same work over again, in order to cleanse the whole satisfactorily, namely, to separate more perfectly any fine dirt particles which may have washed over with the coal. A stream of clear water runs in continually by a pipe *l*, which can be regulated by a valve as shown. The washed coal flows out of the jigger box by the outlet *m*, and is subsequently treated as described hereafter.

RITTINGER'S SPITZ KÄSTEN, OR GRADING BOXES.

The classification of the fine grain, *i.e.*, that below $\frac{1}{4}$ inch, on screens or sieves, would create too many difficulties to make it practicable, so that it becomes necessary to sort it first, and then it is easily classified on the fine coal jiggers. This sorting can be effected in various ways, the best of which is by the employment of Rittinger's Spitz Kästen, Plate XXVII., Figs. 1, 2, and 3. These consist of a series of two hopper-shaped or pointed boxes of a pyramidical shape, with a rectangular base. The dirty coal and water flow into the first and smallest box, and pass out of the last and

* The object of this bed of feldspar is to act as a sieve, the flow of water causing the pieces of feldspar to separate from one another for a few seconds, the grains of dirt having about the same specific gravity as feldspar fall through the intermittent spaces. A sieve could not do this work as the holes would have to be very fine and consequently would soon get filled up, so in this way the sieve itself can be made of much larger mesh.

largest one. The heaviest particles thus sink in the first box, and the next heaviest in the next; so that the water flows out of the last box with very little coal in suspension. The grains thus sorted flow out of the bottom of the boxes in a concentrated stream through the outlet troughs shown in the drawings on to the fine grained jiggers just described.

Having described in detail the construction and action of the principal machines used in Lührig's Coal Washing Establishment, it now remains to give a general sketch of the whole system of dressing as practised at the Brückenberg Colliery (shaft No. 2), Saxony. See Plates XXVIII., XXIX., and XXX.

DESCRIPTION OF THE SYSTEM OF DRESSING.

The coal, as brought from the pit, is either taken to the washing apparatus in a mixed condition of large and small, or, if divided underground into large and small, the latter only is washed.

If the latter plan is adopted at collieries where a large amount of round is made, the washing apparatus is saved a great deal of work. At the Brückenberg Colliery, where the coal is separated underground, from six to twelve per cent. of the total quantity drawn is round (which amounts to 400 or 450 tons per day), of which only from 350 to 400 tons are washed or dressed.

This coal is tipped by means of circular tips or kickups *a* upon screens *b*, where pieces larger than 3¼ inches are separated from the remaining mass. In the modern washing establishments Briart's patent screens are used, the bars of which are worked separately backwards and forwards by their being attached to eccentrics on a revolving axle running at right angles to the bars; the advantage being that the screens can be placed at a less angle than the ordinary screens, gaining thereby a larger screening surface.

The coals that pass over these screens arrive in a sorting table or shelf *c*, where they are separated into the following three sorts:—

1.—Large coal, which is loaded into wagons.
2.—Dirt.
3.—Dirty coal, or coal more or less impregnated with dirt.

The latter by further disintegration is separated into two sorts of clean coal after being washed, viz., cobbles and cube coal.

The disintegration has been effected latterly by stone-breaking machines, which answer the purpose well.

At the above colliery the stone-breaking machine *d* is placed over the sorting shelf, to which the coal is carried by means of an elevator *e*.

Besides the three above-mentioned sorts of coal a fourth class is made, called "fine powdered coal," which no further disintegration and washing can make into a clean product. This is used for firing the boilers, and amounts to one-half per cent. of the output.

The principal collecting hopper *f* lies below the screens into which the coal passing through the screens falls. This hopper should be of large dimensions, to serve as a store, so that should anything happen to stop the pit, enough coal would be ready to keep the washing going; or, should the washing machinery be stopped through accident, the hopper would be large enough to hold the output. It might be of such dimensions to allow the coal drawn during the night shift to be stored, should the washing machinery be large enough to clean all the coal during the day.

From the collecting hopper *f*, the coal, by means of the principal elevator *g*, is brought to such a height as to insure its falling into the revolving screen *h*. This screen is a simple conical drum screen, of which the meshes are $2\frac{1}{2}$ inches wide, so that the large coal is separated from the small, or that under the $2\frac{1}{2}$ inches.

At the Brückenberg Colliery this revolving drum has a second casing, with a mesh of $\frac{1}{4}$ inch, whereby the small coal is again divided into sizes of from $2\frac{1}{2}$ to $\frac{1}{4}$ inch. Formerly the coal passing over the $2\frac{1}{2}$ inch screen went dry upon a travelling belt to a revolving table, there to be divided into clean large coal, a mixture of small coal, and dirt; the former was sold, and the second used for the boilers, or disintegrated by the stone crusher *q*, taken by an elevator into *o*, and washed with the rest.

This arrangement has been changed by the present manager, Mr. Menzel, who found it necessary, owing to the large amount of ashes in the small coal, to adopt washing troughs *i*.

These troughs are inclined at an angle of four degrees, over which the small coal and dirt, mixed with water, flow; whereby the dirt, being heavier, falls first, then the mixed coal, and lastly the lighter clean coal is carried to the draining sieve A′, and from there to a suitable receiver by the conduit A″.

These troughs are in duplicate, so that one may be cleaned without disturbing the washing. By opening a valve *b′* the dirty coal is got rid of, and by the valve *c′* the dirt. For this work, which is only carried on during the day, three men are requisite; while for the former process of separating the coal by means of revolving tables eight women were employed day and night. Besides this saving, however, the coal is better sorted than could be done by means of labourers, especially while working

by lamp light; in addition, the arrangement is cheaper and the cost of repairs is lightened; and there is a saving of power in driving the machinery. A centrifugal pump *k* supplies the necessary water, and, in order to lessen the suction height, does not draw its water from the principal basin *l*, out of which the centrifugal pump *m* draws to supply the jiggers, etc., but from the basin *n*, which is fed by the overflow water from the grading boxes B, which is sufficiently clear for the purpose.

The coal thus washed goes to the hoppers, and the dirty particles washed out and falling through *b'* are crushed and elevated to the revolving screen *o*.

The coal under $2\frac{1}{2}$ inches which passes through the inside screen of *h*, goes to the drum screen *o*, after pieces smaller than $\frac{1}{4}$ inch have been separated by the external screen; this is done to lighten the work of the drum screen.

This screen separates the coal into more classes than is absolutely necessary for the process of separation. Theoretically considered, and supposing the form of the coal to be uniform, a single screen with a mesh of $\frac{7}{8}$ inch diameter would be only necessary to divide the coal into two classes from $2\frac{1}{2}$ inches and $\frac{7}{8}$ inch. In practice, however, commerce demands a further division, and at this colliery five classes are made by hoppers *rr* around the principal drum screen *o*, with meshes of $\frac{1}{2}$, $\frac{3}{4}$, $1\frac{1}{4}$, and $1\frac{3}{4}$ inches diameter, as follows:—

Class 1.— $\frac{1}{4}$ inch	... ...	Nut coal	No. II.
„ 2.— $\frac{5}{8}$ „	... ...	Do.	No. I.
„ 3.— $\frac{3}{4}$ „	... ...	Cobbles.	
„ 4.—$1\frac{1}{4}$ „	... ...	Cube coal	No. II.
„ 5.—$1\frac{3}{4}$ „	... ...	Do.	No. I.

The last two classes are often mixed together after being washed, and are only separated during the washing so as not to overload the last screen.

The coal, on entering the principal drum screen *o*, is met with a powerful jet of water for the purpose of soaking it, and besides, each screen, half-way up the rising portion, is strongly squirted with water to clear the coal sticking to the meshes, which quickens the classifying process. The necessary amount of water is pumped by means of the pump *m* from the drainage troughs *p* of the settling basins.

Besides the coal from the drum screen *h*, the drum screen *o* takes the mixture of coal and dirt that falls through the hole *b'* of the washing troughs before described, which, after being disintegrated, is lifted by means of an elevator. The five classes are brought through the hoppers *r* to the five jiggers *s* below. These jiggers deliver the

dirt which sinks on the screen, which is heavy enough to resist the upward motion of the water, and which passes through an opening in the side, and by means of a bucket wheel is taken away and allowed to fall into a passage *t*. Usually the jiggers pass the dirt to the dirt heap either upon a horizontal passage or by means of an Archimedian screw, but here the dirt is brought from each jigger by passing down a steep passage *t* in the dirt hopper *u*, when, by means of the elevator *v*, it is brought to a place where it can be taken away.

The dirt which falls through the meshes of the screen upon the bottom of the jigger, and passes the valve *b'*, Plate XXV, also goes into the passage *t*.

At last the jigger delivers the washed coal with mud. The mud, or fine coal and water mixed, is dealt with according to the manner in which the drum screen screens the coal. If the drum screen separates the fine coal from the rest, then the amount of mud in the jiggers is small; if this is not the case, then the first jigger receives the greatest amount of mud which is required for the fine grain jiggers.

Both coal and mud pass through a slit in the side of the jigger, and from there are dealt with in different ways. In the old method a slanting sieve *z'* was placed to allow the water to pass through and the coal to be brought to a hopper *z*, or if there was no room below this, a small elevator took the coal to a loading hopper and an elevator was necessary for each jigger, or for each separate sort of coal.

Instead of this transport arrangement, which gave great trouble and expense in repairs, the present method, invented by Mr. Berg, simplifies the process materially. Here the mud and water are used for transport, as with the washed coal they pass over passages inclined at an angle of four degrees, the coal being separated by a sieve from the water just before entering the loading hoppers. At the Brückenberg Colliery the arrangement is as follows :—

The passage *w* brings the water and coal along to a sieve *x*, by means of which the fine coal separated from the water falls into the hopper *y*, and if the sieve *x* has meshes only allowing coal and dirt below $\frac{1}{4}$ inch to pass, the fine coal and water pass direct to the fine coal jiggers; when, however, the mesh of the sieve is larger, a class of coal too good for the fine coal jiggers is passed through the sieve. In such cases the muddy water that escapes is passed over a sieve with a mesh of $\frac{1}{4}$ inch, and is then caught by an elevator and mixed with the nut coals.

The mud, coal, and water passing through this screen are brought

through the passage A to the pyramidical boxes B; into these boxes also comes the coal by a passage C from the $\frac{1}{4}$ inch outer screen of the revolving screen *h*, which already has been thoroughly soaked with water.

In cases where the fine coal is very much mixed with dirt, as at Brückenberg, another coarse coal jigger is placed in the mud stream for the purpose of taking away a great part of the coarse dirt before the mud reaches the pyramidical boxes B and B.′ This jigger is not shown in the drawing. The pyramidical boxes deliver, first, a quantity of grains of coal and dust; secondly, water which passes along the passage D and which holds in suspension the finest particles of coal and dirt, part of which is used for the feeding of the centrifugal pump *k*, mentioned before, while the remainder flows into the settling basins. From each pyramidical box the coal and dirt fall into the fine coal jiggers, so that for each box such a jigger is required. In this case there are two, E being fed from the box B, and E′ from box B′. In these jiggers the feldspar separates the coal from the dirt; the former mixed with water passes along the passage F over a sieve to a hopper G, out of which, by means of a Jacob's ladder H, the buckets of which are pierced with holes, to a loading or reserve hopper. Should the mud contain fine divided particles of iron pyrites, a sieve is introduced, with a mesh of about $\frac{1}{32}$ inch wide; when this is elevated it is necessary to squirt clean water into the buckets by means of a hose.

The mud that passes through the sieves is taken to the depositing basins.

Along the passage J pass at last the dirt and mud from the mud jiggers to the dirt basin *u*, where, with the rest of the dirt from the coarse coal jiggers, they are lifted by means of an elevator *v*.

During the work water is constantly flowing from the cistern K, which is fed by the centrifugal pump *m* through the pipes L to all the jiggers.

Finally, it may be mentioned that the steam engine M of 25 horse-power works the whole of the apparatus. At present, however, the washing is only done during the day, there not being enough work to keep all going during the night. The screens *b*, the crusher *d*, and the elevator *e* are worked by means of a small engine, not shown in the drawings, during the night.

The coal as brought from the mine, being assayed before washing, gives 25 per cent. ash (pieces of pure coal contain 2·3 per cent. ash). This high percentage is reduced to 5 or 6 per cent. by washing, so that from 19 to 20 per cent. of the dirt is got rid of; thus 2·7 to 3·7 per cent., or, taking as a medium, 3·2 still remains as impurity in the coal. Coal care-

fully cleansed by hand only gave ·1 per cent. less ash, so that the highest possible degree of cleansing seems to have been attained. The remaining impurity of 3·2 per cent. is made up chiefly from thin plates of calcspar and iron pyrites adhering to the coal, and not from free pieces of dirt.

The total consumption of water consists of 660 gallons, with an addition of 22 gallons of fresh water per minute—that is, 50 gallons of water are required for one cwt. of coal. M. Lührig has guaranteed to wash 800 cwts. of coal per hour with a maximum of 6 per cent. of ash, the coal ranging from ½ inch downwards, for making coke. These results have been perfectly attained.

TABLE OF RESULTS AT BRÜCKENBERG (SHAFT No. 2.)

1877.	Piece Coal.		Mixed Coal.		Coal Impregnated with Dirt.		Total Output in Tubs.
	Tubs.	Percentage of Total Output.	Tubs.	Percentage of Total Output.	Tubs.	Percentage of Total Output.	
August	1,205	5·99	18,618	92·54	295	1·47	20,118
September ...	1,252	6·20	18,725	92·68	227	1·12	20,204
October	1,562	6·77	21,377	92·59	149	0·64	23,088
November ...	1,491	7·29	18,827	92 08	129	0·63	20,447
Total.....	5,510	6·57	77,547	92·48	800	0·95	83,857

The following table shows the wages given in the coal-dressing establishment:—

Wages for	August. 18,618 tubs or 204,798 cwts.			September. 18,725 tubs or 205,975 cwts.			October. 21,377 tubs or 235,147 cwts.			November. 18,827 tubs or 207,097 cwts.		
	Amount.			Amount.			Amount.			Amount.		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Engineman	6	13	9	3	17	9	4	5	0	4	1	0
Sorting at the screens	16	2	1	15	14	7	20	15	2	18	5	10
Removal of coal and dirt from screens ...	2	14	2	2	10	7	3	1	2	1	12	9
Labour at the troughs	9	12	11	9	9	8	11	0	0	9	6	9
Labour at the coarse jigger	3	17	0	3	8	8	4	3	9	3	10	4
Labour at the fine jigger	3	15	4	3	9	7	4	3	8	3	9	1
Labour at reservoir	2	4	3	2	6	0	2	8	5	2	2	2
Cleaning out of the mud reservoir, and removal of the mud from settling coal ...	8	14	11	10	0	3	14	3	9	12	18	0
Cleaning out canals...	1	6	5	1	7	3		17	4	1	4	5
Sweeping and cleaning up under the hoppers	3	13	10	3	7	7	5	16	2	3	6	9
Removal of washed dirt	8	0	6	9	0	0	10	1	3	8	6	4
Man at the hoppers for loading	8	12	8	9	16	4	10	0	10	8	8	6
Loading and packing	10	0	7	9	2	7	13	19	2	10	5	6
Total	85	8	5	83	10	10	104	15	8	86	17	5

From the foregoing table the average of these four months would be about one-tenth of a penny per cwt. for labour. M. Lührig quotes the price of his coal-washing establishments, with a capacity for washing 1,000 cwts. per hour during ten hours a day, including all extra plant, such as loading apparatus, settling beds, etc., at £2,700 to £3,500. Taking a medium, therefore, of £3,100, and reckoning the interest at 5 per cent., the amortization as 10 per cent., and the repairs at 5 per cent. (total, 20 per cent. of the outlay, or £620 yearly), and reckoning 290 working days per year, the daily cost would amount to 42s. 9d. a day; a little over ·051 of a penny a cwt. for depreciation of plant and interest of capital, or threepence a ton for labour, depreciation, and interest on capital.

The output of the various classes of washing can be gathered from the following Table :—

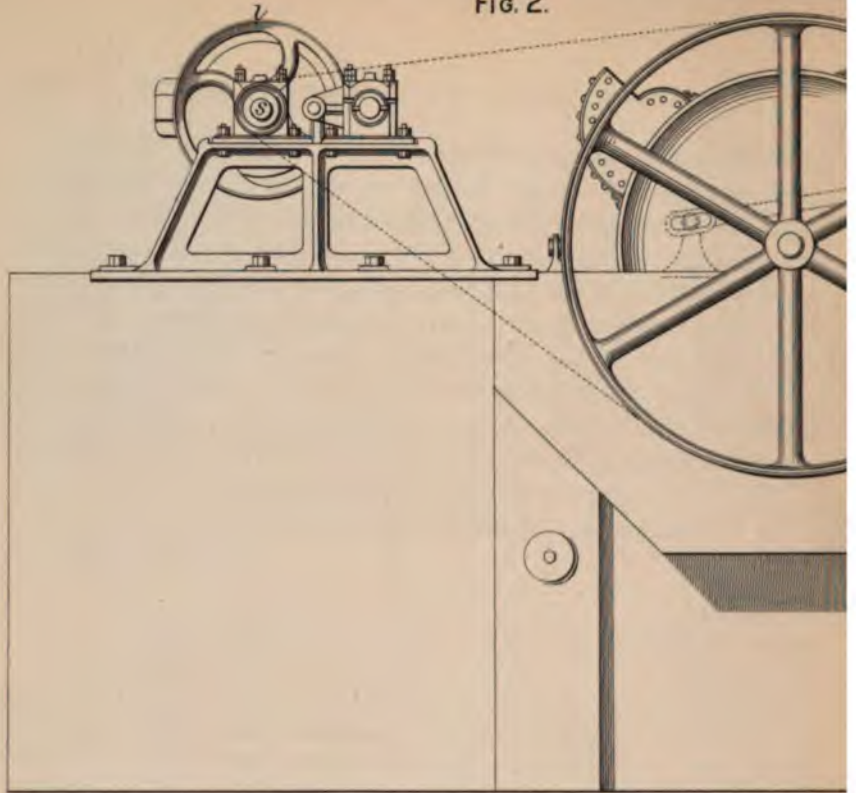
1877.	Piece Coal. I.	Piece Coal. II.	Cube Coal.	Cobbles.	Nut Coal. I.	Nut Coal. II.	Coke Coal.	Mud Coal.	Coal impregnated with Dirt.	TOTAL.
August	3,032	1,005	3,941	3,235	2,606	1,400	1,719	1,746	219	18,903
September.....	3,330	886	3,762	3,102	2,708	1,140	1,539	1,616	616	18,699
October.....	3,997	820	4,383	3,561	2,987	2,018	1,539	1,318	839	21,462
November.....	3,627	717	3,657	3,018	2,405	1,372	1,196	1,172	606	17,770
TOTAL TUBS...	13,986	3,428	15,743	12,916	10,706	5,930	5,993	5,852	2,280	76,834
Percentage.....	18·259	4·462	20·489	16·810	13·934	7·718	7·799	7·616	2·967	

Plate XXXI. shows in the form of a diagram the way the coal is passed through the several screens and machines.

The CHAIRMAN, in proposing a vote of thanks to Mr. Rathbone for his paper, drew a comparison between the very exhaustive method of treating the coal at Zwickau and the very primitive appliances that were first introduced in England, where a large quantity of coal was lost in order to cleanse the remainder of about 18 per cent. of the rubbish it contained. Even the very much more perfect arrangements introduced from France by the late Mr. James Morrison did not come up to the standard of perfection now described. But before introducing machinery of so costly a description it would be as well to consider if the amount of water required, which seemed to be very large, would not exceed that which might be readily attainable, and also whether the cost of cleaning would not be too high to render the arrangement of practical use in England.

To illustrate Mr E.P. Rathbone's paper

FIG. 2.



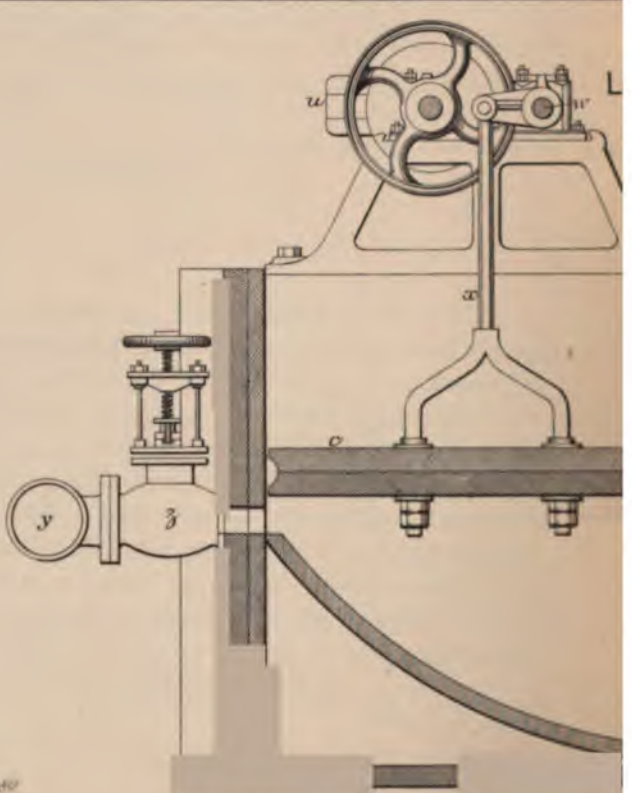


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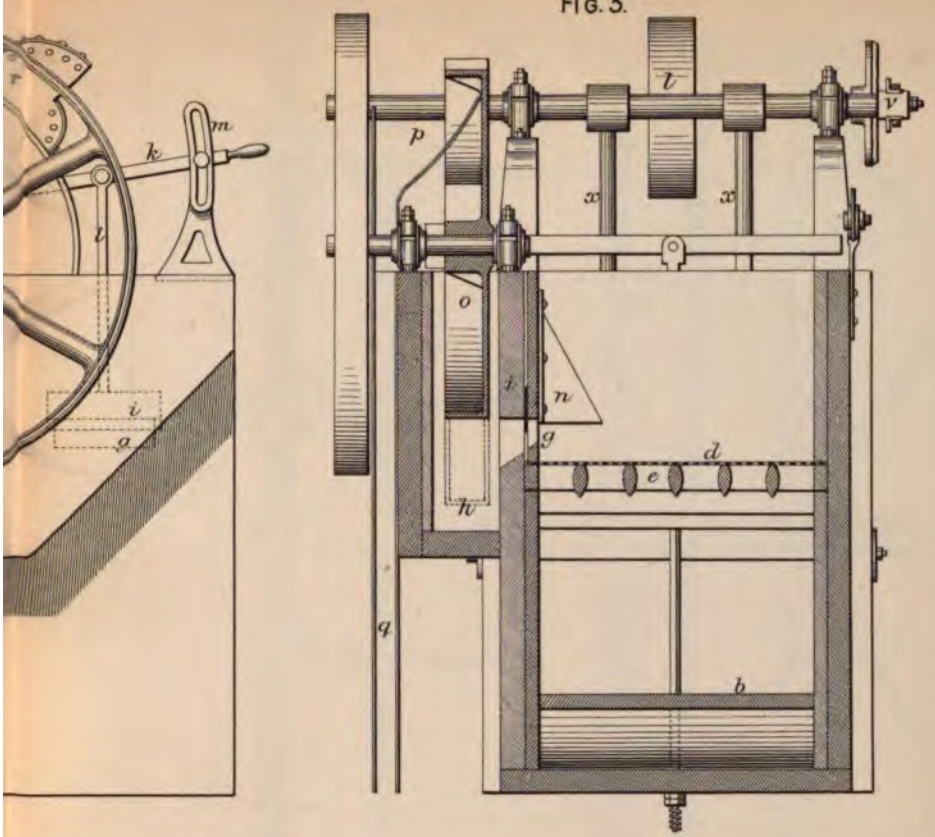
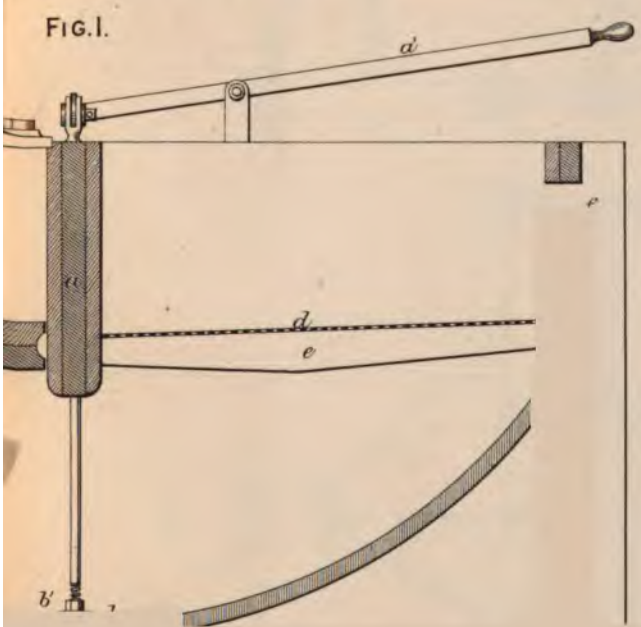
FIG. 3.



IG'S COARSE COAL JIGGER.

FIG. I.



LÜHRIG'S FINE COAL JIGGER.

FIG. 1.

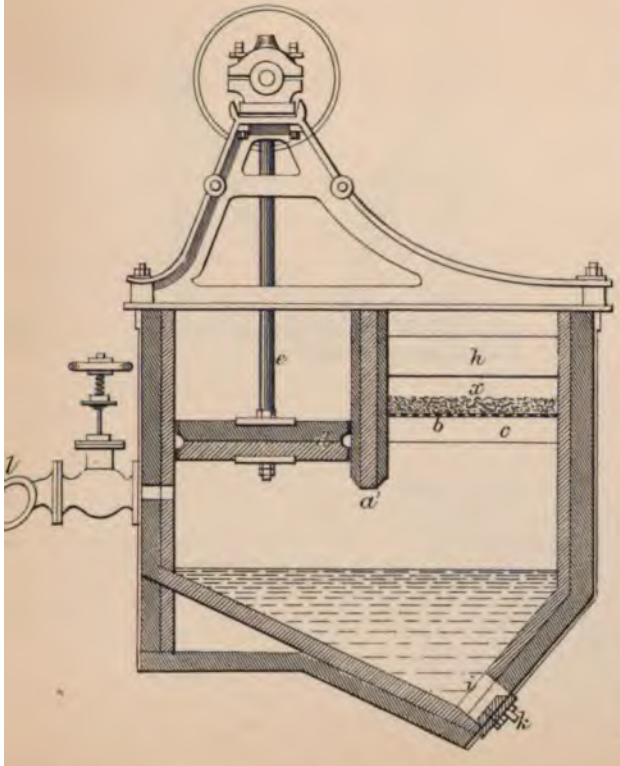
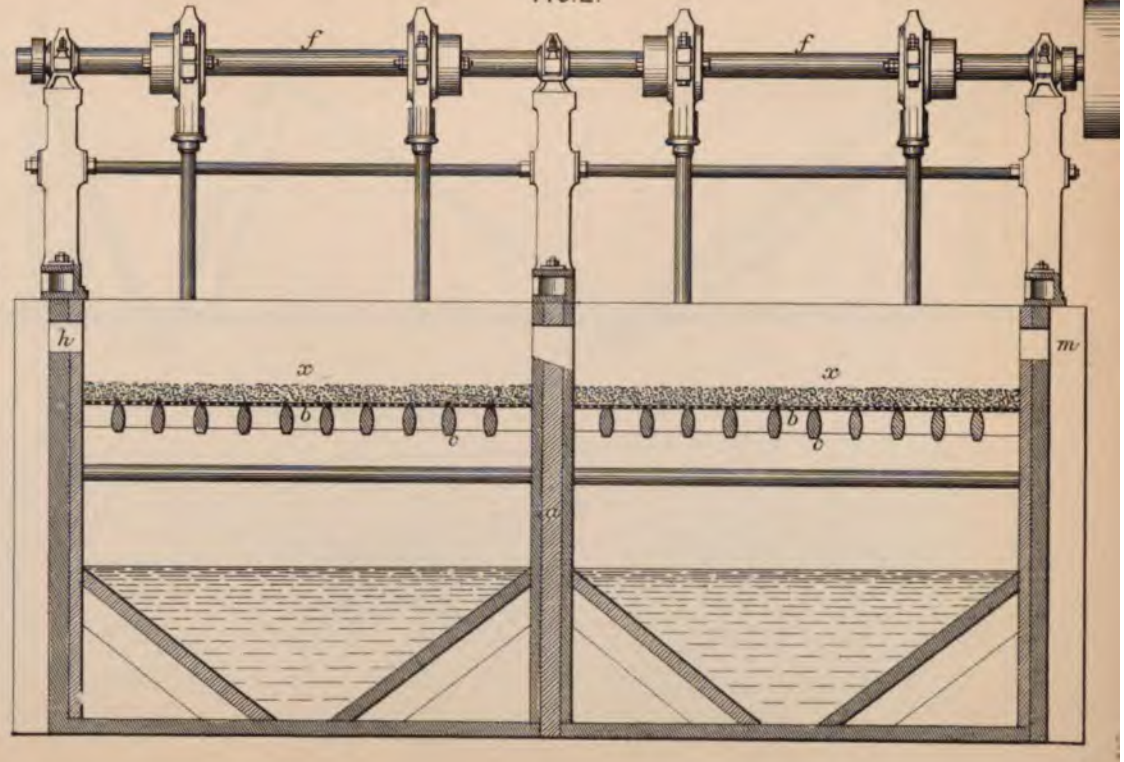


FIG. 2.



Proceedings N.E.I. of M. & M.E. 1879-80

Jas. Todd Newcastle

Fig. 1.

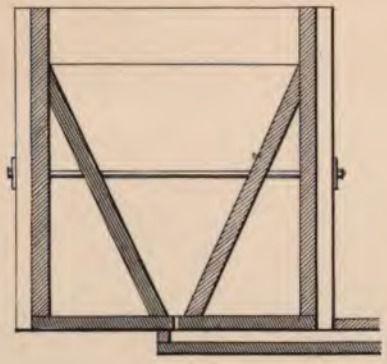


Fig. 2.

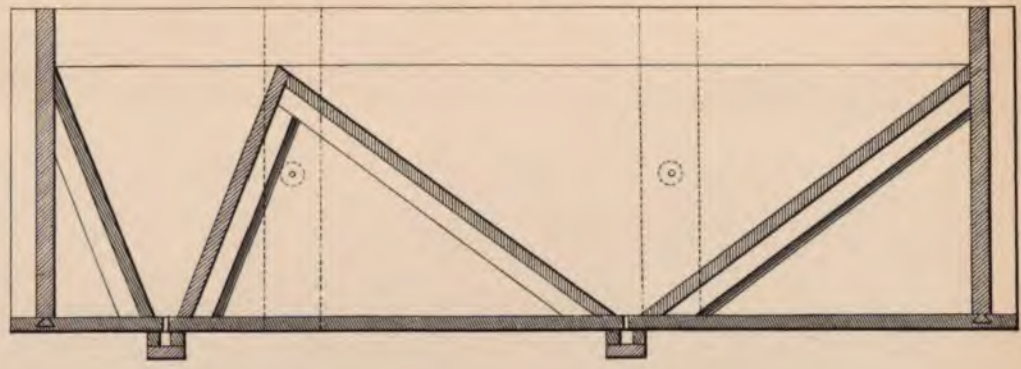
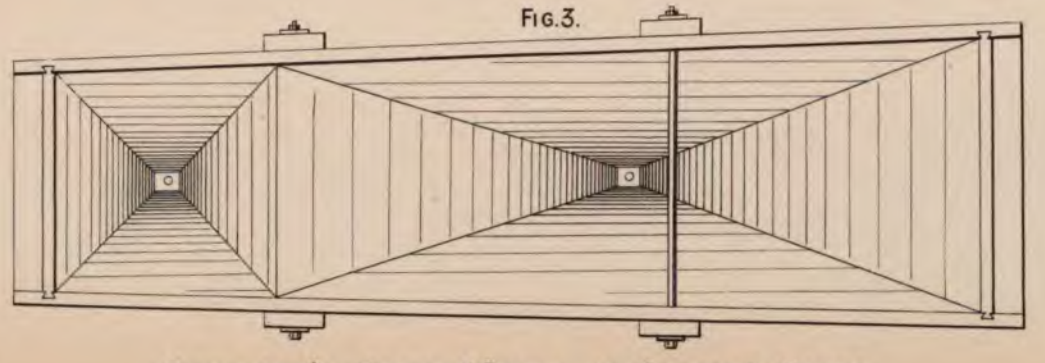


Fig. 3.

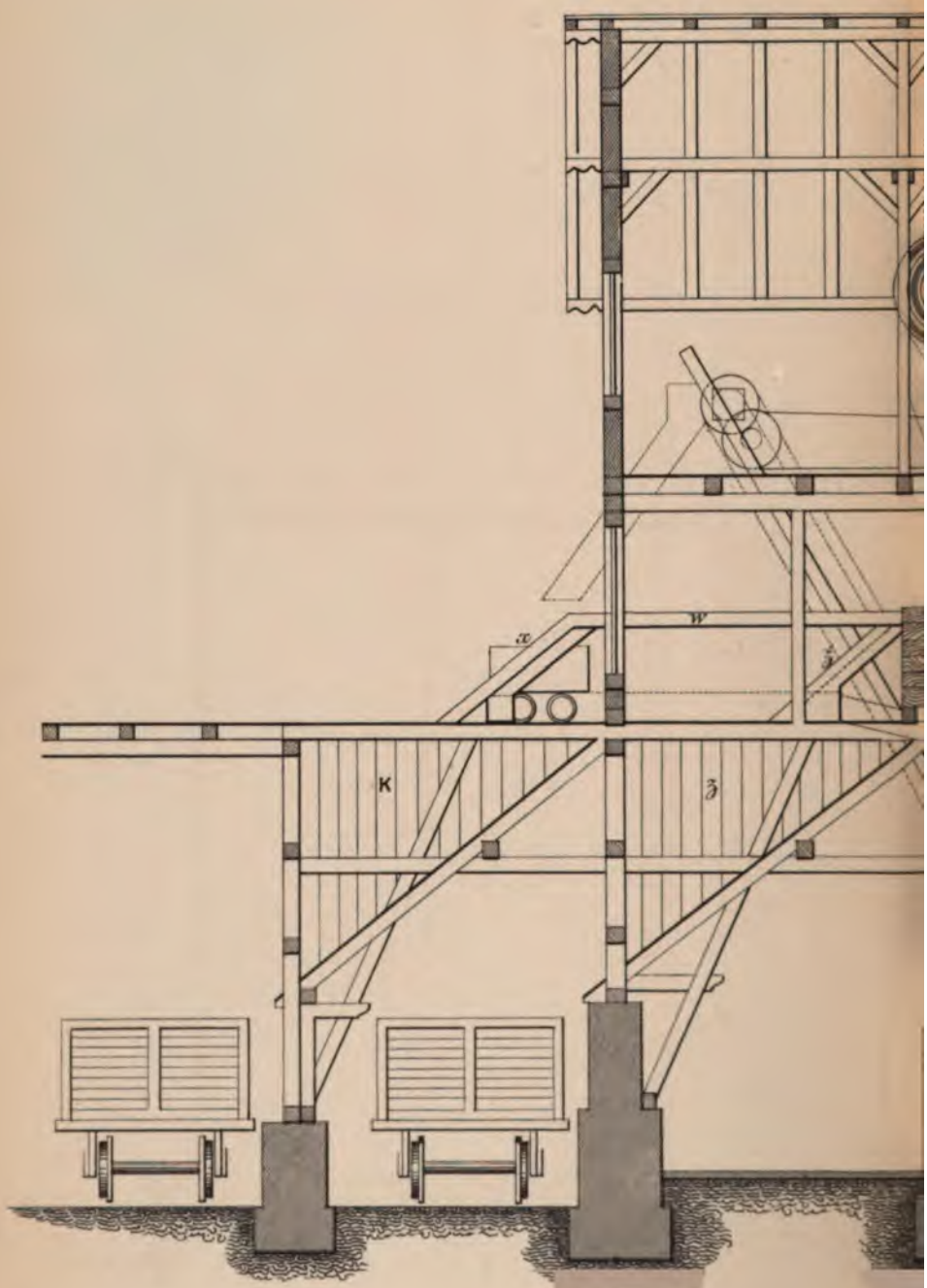


RITTINGER'S SPITZ-KÄSTEN OR GRADING BOXES.

Art. Type & Newcastle

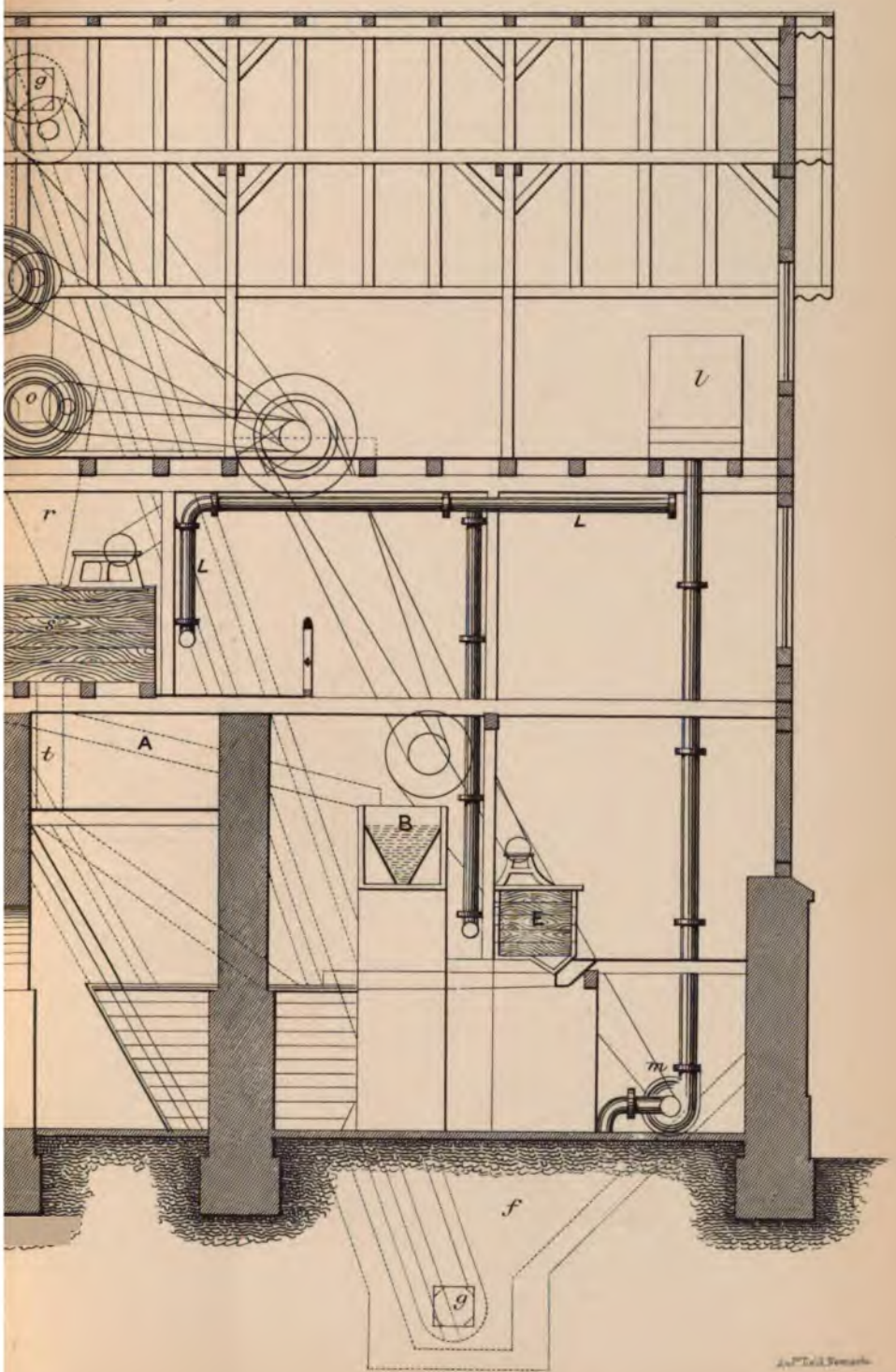
To illustrate Mr. E.P. Rathbone's pape

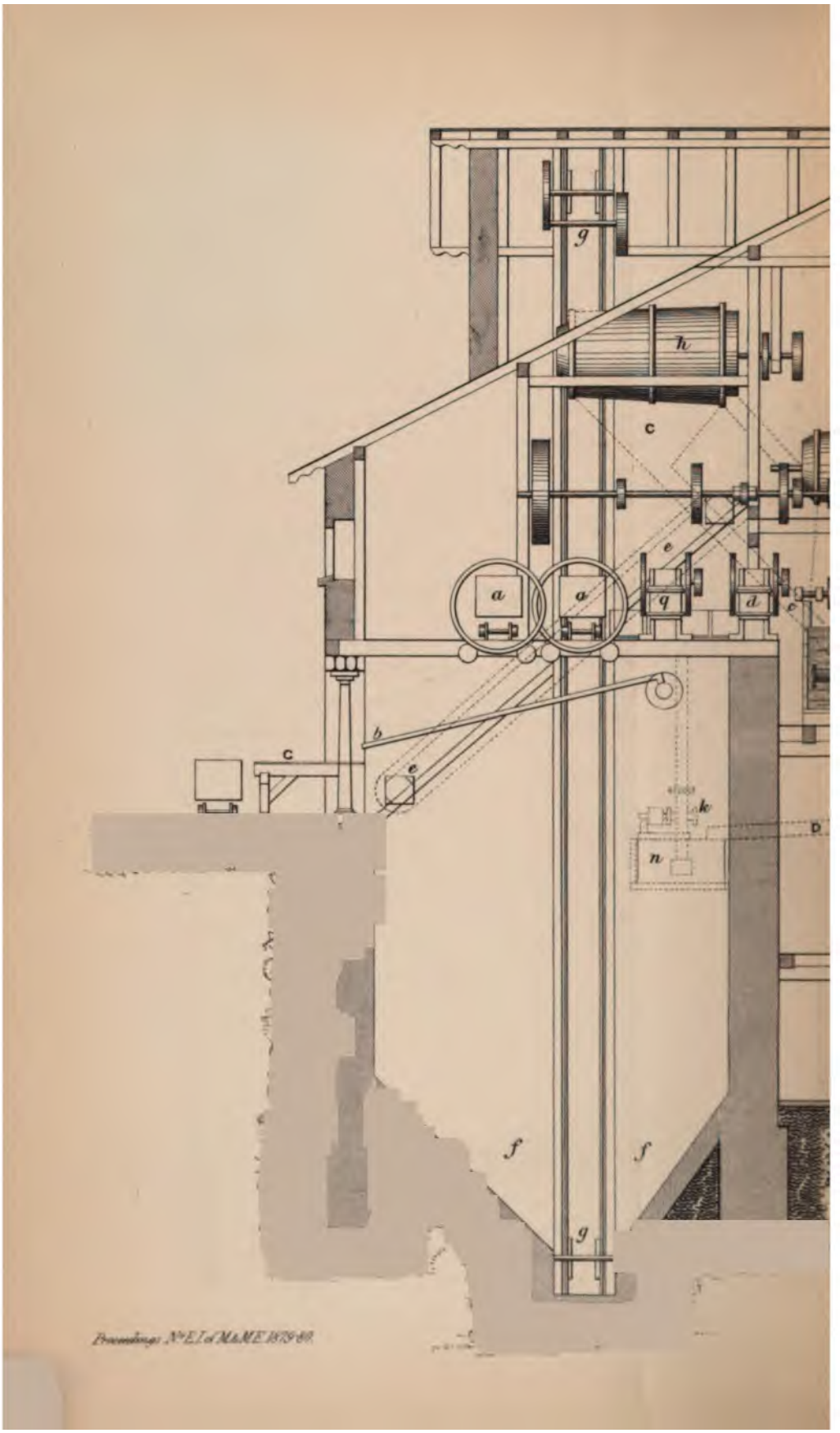
LONGITU



on Lührig's Coal Washing Machinery"

INAL SECTION.





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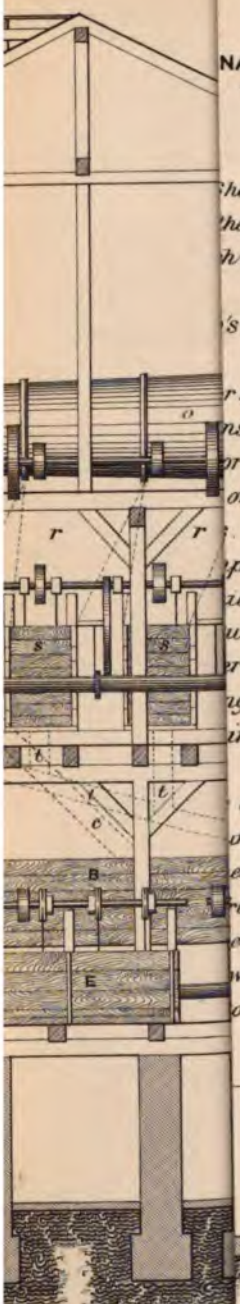
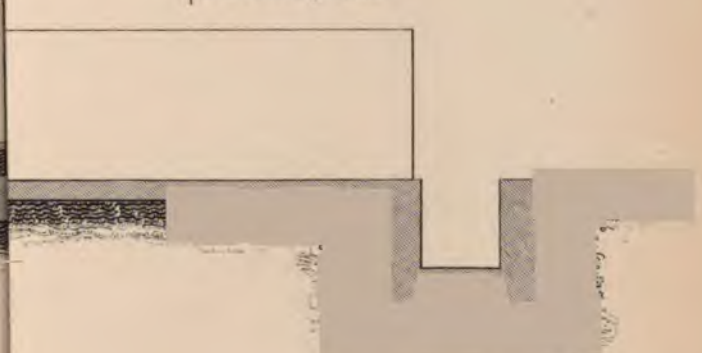


NATION OF THE LETTERS IN PLATES.

- shelf.
- he crushing of the
- h is brought to the
- 's ladder which
- r hopper, for all
- ns.
- or.
- or Drum Screen.
- ps for i
- ach
- ump raises water
- rs
- g Pump k.
- ing revolving
- clear water from
- mp m
- erly used for crush-
- rom revolving
- lt for hopper f.
- which the classi-
- o

s. The coarse Coal Jiggers
t. Passage for dirt to
u. Dirt basin.
v. Dirt elevator.
w. Passages for the classified Coal to hoppers.
x. Sieve for separating water belonging to w.
y. Hoppers for classified Coal.
z. Hopper for the Coal and water passing through sieve z now done away with.
A. Passage for Mud Coal to the draining Sieve
B. Pyramidical Boxes.
C. Passage for dust Coal from revolving screen h to B.
D. Overflow passage for water from B. to the Cistern n for pump k.
E and E'. Two Mud Coal Jiggers.
F. Passage for taking washed Coal from Fine Coal Jiggers to
G. Hopper out of which
H. Elevator lifts.
J. Passage for dirt from Fine Coal Jiggers to u.
K. Washed Coal Hoppers
L. Pipes for supplying water to Jiggers.
M. Steam Engine
A'. Draining Sieve



Lith. Reid, Newcastle.

MAINE 1879-80.

Mr. W. COCHRANE, in seconding the vote of thanks, referred to the tabular statements which had not been read, but which conveyed a great amount of valuable information.

The vote of thanks was unanimously responded to; and the members adjourned to the Laboratory of the College of Physical Science, kindly placed at their disposal by Professor Freire-Marreco, to hear Professor Forbes, of Anderson's College, Glasgow, describe his instrument for ascertaining any small quantity of gas there might be in the workings of a mine.

Professor FORBES stated that his attention had been first drawn to the subject by his friend Mr. James Young, F.R.S., of Kelly, shortly after the disastrous Blantyre explosion in 1877. The form the first suggestions took was not very practical, but they afterwards became elaborated into the convenient and practical instrument he had the honour now to exhibit. This instrument depended on a well-known principle in acoustics: that the sounds produced by the vibration of a tuning fork placed over a column of air confined in a tube would become very much more audible when the column in the tube was of the length suited to the pitch of the note produced by the fork, and that the length of this column was influenced by the specific gravity and nature of the various gases which the tube might contain. The instrument (see woodcut) was therefore composed of a tuning fork, *a*, placed over a tube *b*, the length of which is regulated by a piston *d*, moved up and down by a rack and pinion actuated by a large milled head *c*, the amount of motion given to which is indicated by a pointer. When used the metal rod *e* is inserted between the limbs of the fork and drawn sharply through them, and the vibrations thus caused become distinctly audible only when the tube is of suitable length. If, therefore, the fork which was audible with a certain length of tube ceases to be so, it shows that the condition of the air in the tube has undergone a change, and become either more or less mixed with gases of different specific gravities, and the amount of such change is indicated by the pointer. If, therefore, the air is contaminated with fire-damp, the mixture will be of different quality to, and less specific gravity than, pure air, and the tube

will have to be lengthened to cause the vibration of the tuning fork to be audible; and if a properly graduated index is fitted to the tube, this amount of increase in length may be made to indicate the exact amount of fire-damp in the mixture.

A correction has to be made for temperature, variations in which also affect the column of air, and to make these corrections, a thermometer, *f*, was attached to the instrument; this thermometer was not graduated in degrees in the usual way but registered certain variations in figures which corresponded with and had to be subtracted from the figures, showing the length of the tube and the amount of the fire-damp, the result giving the correct percentage of fire-damp in the tube.

In order to give to the hand greater control over the lengthening and shortening of the tube, a rack has been attached to the piston, which works in a pinion on whose axis there is a large disc, *c*, with a milled head 3 inches in diameter. This disc has a glass face with a graduated scale round the circumference; so that a fixed index marks with great precision the exact length of the tube. The scale is thus made so large that readings can be made in the feeblest light.

That the instrument may be taken in advance of a lamp in places where gas is expected in large quantities, a phosphorescent powder is placed in a cavity behind the graduated glass plate, so that readings can be taken in the dark.

To be sure that the gas or air in the tube is the same as what is to be found in the particular part of the mine under examination, there is introduced, through the piston worked by the pinion, a rod, at the upper end of which is a packed disc fitting the tube tightly. Previous to taking a reading this disc is, by means of a handle attached to the rod, driven up to the open end of the tube, and when drawn back it sucks in the air from the place under observation, and by a single turn of the handle, locked to the piston which works the pinion, by a bayonet joint.

The following is a description of the apparatus used for testing the accuracy of the scale:—A circular trough 4 feet diameter and 3 inches deep, was partially filled with water, and a grating placed over the water to stand upon. In the centre of the trough there was a hole with an inch metal tube projecting upwards 4 inches. To this was attached an India-rubber tube 2 feet long, with a mouthpiece which could be firmly attached to the mouth for breathing. The operator sat on a stool above the water with the mouthpiece attached, and the nose closed by spring pincers, and a tin cover 4 feet high and 3 feet diameter was lowered over him into the water. There was a small hole in this cover, with glass over it, at which

a light was held on the outside. Different quantities of marsh gas were then admitted under the cover, which were mixed with the air by means of a fan. A reading was taken with the instrument, and at the same time a bottle of water was emptied and closed air-tight. The contents of the bottle were afterwards analysed; and thus the true percentages, corresponding to different readings of the scale, were obtained.

In this way it is possible to measure the proportion of fire-damp to about one-half per cent. of the volume of the mixture.

These experiments had been verified by his colleague, Professor Dittmar, who at different times had analysed the contents of the bottles filled in the cylinder and had found them to agree within one-half per cent. of the readings of the indicator, and this seemed at present to be the limit to which a practised ear could reach in using the instrument.

Experiments were then made before the members showing that amounts of gas varying from a trace to 20 per cent. could be readily detected by the instrument.

Professor FORBES continued—Where carbonic acid gas was present in the mine it of course increased the specific gravity of the mixture, and modified the indication on the instrument. But the choke-damp diminished the explosiveness of the fire-damp in about the same proportion; for example, if there was a mixture of 6½ per cent. of fire-damp and 1 per cent. of carbonic acid gas, the instrument would indicate a figure due to about 4 per cent. of fire-damp; and as a mixture of 6½ per cent. of this gas with the atmosphere is explosive and 4 is not, this alteration in the reading would be very serious were it not that the presence of the carbonic acid gas rendered the mixture as harmless as it would have been had it only held the 4 per cent. of fire-damp indicated by the instrument, as, to use an expression common among the miners of Scotland, the carbonic acid gas "damped" the marsh gas. Of course the instrument could be made to indicate the absolute quantity of marsh gas even when carbonic acid gas was present, by adding an apparatus whereby the mixture to be examined could be passed through water before it entered the tube of the machine and the carbonic acid gas absorbed, but he con-

sidered from the above reason that such an addition was perfectly unnecessary, and would only serve to render the apparatus more cumbersome, while at present it was one of extreme simplicity, and could be worked by any one with ease and accuracy. Moreover, Dr. Angus Smith had shown that 2 per cent. of carbonic acid gas extinguishes a candle or lamp.

He had taken the instrument down many mines, and one remarkable fact had been elicited by its use, namely, the very uncertain nature of any test for gas made by a Davy, a Clanny, or any other safety-lamp. He had tested many such lamps and found they would not show a blue cap when 5 per cent. of marsh gas was present; and he really thought, as a matter of fact, these lamps were not sufficiently delicate to be relied on.

The CHAIRMAN said, he was sure that they would all join in a vote of thanks to Professor Forbes for the trouble he had taken in bringing his very clever invention before them, and for the very interesting illustrations he had exhibited, and he hoped that the instrument would be the means of initiating valuable researches in mines which are more or less subject to great discharges of gas.

Mr. A. L. STEAVENSON, in seconding the vote of thanks, said that he was the first to ask Professor Forbes to come over, and he felt very much obliged to him for the courteous way in which he had acceded to the request. It was of the utmost importance to all persons who had devoted their attention to the perfection of such instruments that they should be freely criticised by those whose calling it was to use them. One of the chief uses of such a machine was to enable the engineer of the colliery to rightly estimate the amount and nature of the gases in the air returns so as to ascertain if there was any deficiency in the ventilation, and he thought that an instrument which only indicated that the air in the mine approached more or less to the explosive points without indicating the percentage of fire-damp was imperfect in a very important particular, and, therefore, he considered the Professor's explanation of the nature of the indications, when carbonic acid gas was present, hardly satisfactory, and any machine which might, under circumstances very likely to occur, register only 4 per cent. of gas when 6 per cent. of fire-damp was present, was scarcely to be relied upon, and in this respect he thought the invention of Mr. Liveing, described in page 287, Vol. XXVII. of the Proceedings, much superior. This instrument, even when carbonic acid gas was present, indicated one-

fourth per cent. of marsh gas with unerring certainty. The Professor's instrument was, however, decidedly the most handy and portable, but he thought the results obtained by that of Mr. Liveing were more reliable.

Mr. JOHN COOKE thought that changes in the barometrical pressure might influence the readings of the instrument, and would be glad to hear more at length from the Professor the reason for supposing this not to be so. He would also like to know the price of the instrument.

Professor FORBES, in replying to Mr. Cooke, said that it must be recollected that the instrument was simply a machine for registering the velocity of the sound wave which depended on the elasticity and density of the medium through which it is transmitted, and as any increase or decrease in the density of any given medium is accompanied with a corresponding increase or decrease in its elasticity, the velocity of sound will always be the same under any pressure in the same medium, although susceptible of great variation when the component parts of the medium are changed. With regard to the second question, the price of the instrument was £10.

Mr. LIVEING then exhibited the instrument he had invented. He stated that he had frequently tested the instrument both above ground and in the workings of a pit, and found that it invariably detected quantities of gas to a quarter per cent. He found that the presence of carbonic acid gas, to the extent of 2 per cent. in the mixture experimented upon, did not practically alter the reading. The point to be remembered was that the instrument gives the heating value of the gaseous mixture examined, or in other words, its approach towards the explosive point; the presence of carbonic acid gas only affects the readings to the extent that it diminishes the heating value. In the case, however, of an instrument dependent on the physical properties of the mixture (as was Professor Forbes') the presence of carbonic acid affected the reading, but not in the same ratio as it affected the heating value.

The vote of thanks to Professor Forbes having been unanimously adopted, the meeting terminated.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, APRIL 17TH, 1880, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

J. B. SIMPSON, ESQ., IN THE CHAIR.

The SECRETARY read the minutes of the last meeting and reported the proceedings of the Council.

The following paper "On the Strength of Wrought Iron in Compression," by Mr. WIGHAM RICHARDSON, was then read:—

ON THE STRENGTH OF WROUGHT IRON IN COMPRESSION.

By WIGHAM RICHARDSON.

The writer hesitates to some extent in bringing the above subject before the members of the Institute, seeing that he has no new facts, data, or experiments to lay before them; but he wishes to express some doubts about generally received hypotheses, and, in so doing, to invite discussion and an interchange of ideas.

It is now nearly twenty-five years ago since Professor Eaton Hodgkinson made certain remarks before the writer on the premises of University College, London, where he made his experiments, and it is to these remarks that attention is called.

Professor Hodgkinson, whose experiments are even now the generally accepted data for all deductions about the strength of wrought iron in compression, then said to his class—"Remember that although a piece of wrought iron one and a-half inches long and three-quarters of an inch diameter will crush with a load of something like sixteen tons per square inch, we do not know, if the sectional area be increased, that the limit of crushing strength will be increased in the same proportion."

This is the remark of the Professor, and yet the writer thinks that he would be correct in saying that, notwithstanding this, the usual practice of engineers has been to consider wrought iron as weaker in compression than in tension, whatever the section of the structure may be, and justified in asking, is this common sense? For instance, a tall chimney may be built of bricks without crushing the lowest course of its brick-work, but if a little pillar, one inch square and two and a-half inches high, were to be sawn out of a brick, such a little pillar would not support the proportion of the load due to it. It would crumble to pieces. In other words, twenty square inches of brick are more than twenty times as strong as one square inch. Perhaps a more striking illustration would be this: When any excavation is going on it is usual to leave here and there cones of the supersoil to mark the original height of the ground. These cones, if of

small diameter, are most readily crushed, but if they are left so as to be two or three feet in diameter for every foot of height, they will bear many tons weight with safety.

One of the most recent works on the strength of structures is that written for the "Science Text Book" series, by Mr. John Anderson, the well-known Director of the Woolwich Arsenal, and he thus describes the effect of crushing wrought iron cylinders when the load is taken off before fracture:—

"By increasing the stress upon these short cylinders of wrought iron or soft steel, they are found to shorten gradually by bulging outwards in the middle. The effect of this change of form is to slightly stiffen the metal, and this affects the malleable or flowing property; unless the specimen is extremely soft it will soon show symptoms of slight fissures or cracks at the part which is bulging. To prevent this the annealing process must be resorted to, and with care the pillar can be flattened down to a thin disc, gradually presenting a larger surface for the machine to act upon. Reckoning the intensity of the ultimate pressure from the original dimensions a stress of upwards of 100 tons per square inch is necessary to actually flatten down wrought iron."

When Professor Hodgkinson was making his experiments he did not, so far as is known, try the annealing process, at least those cylinders which the writer saw tested were actually broken. They all broke in the same way; a bulging out at or below the middle, and then a kind of telescopic shutting up, the lower part an irregular cone, the upper part being hollow. Plate XXXII., Fig. 1.

In these experiments the cone was always on the lower side, but it did not seem very clear why this should be the case.

Looking again at Fig. 1, it is evident that if these small pillars had been hexagonal, and several standing close together and held together, they would have given each other much mutual support, and the initial bulging would have been checked.

If this be admitted, the difficulty of calculating the strength of any structure in compression is not lessened. It is easy to speak of so much per square inch if only the strength did not increase in a more rapid ratio than the section.

Although wrought iron is commonly supposed to be weaker in compression than in tension, perhaps no one has ever seen a case in actual practice of wrought iron being crushed. In some cases it is difficult to conceive that pieces of machinery would break as they do, if iron were really weaker in tension than in compression. For example, the writer

remembers seeing an eccentric rod break in consequence of the slide valve seizing. The engine was making at least one revolution each second, and therefore there was a pulling and a crushing strain rapidly repeated. Notwithstanding this the eccentric rod, which was of excellent iron, had drawn out, like a piece of dough or putty, and then broken.

Mr. John McFarlane Gray, of the Board of Trade, wrote a most valuable report upon the breaking in two, at sea, of the paddle-wheel steamer "Mary," built on the Clyde, and he demonstrated that the upper works gave way in compression and not in tension; but, at the same time, he showed that this was not by crushing in the iron, but by repeated bulging and straightening, whereby the honest iron was ultimately obliged to yield.

Again, a ship built on the Wear some ten or twelve years ago, when being towed down to the dock, struck her mast against the bridge and it snapped off at the deck, but there was not any appearance of crushing when the fracture was examined.

On another occasion at works close to those of the writer, the guy of the shear legs gave way, and the legs, which were wrought iron tubes, snapped in two, but on the most careful examination of the broken pieces no appearance of actual crushing could be detected.

The late Sir William Fairbairn, in his work on "Iron Ship-building," gives (pp. 47–63) an excellent summary of the elaborate experiments which were made on the strength of iron tubes at the time when the Menai Tubular Bridge was being designed. He gives a series of illustrations of the way in which these tubes gave way, which, in every case was by bulging. Fig. 2 is a fair sample of these.

He also states that the strength of such columns varies as their widths *multiplied by the cube of their thickness.*

Taken from his tabular list of circular tubes, the strongest of them, which was 10 feet long, $6\frac{3}{4}$ inches diameter, $\frac{1}{8}$ inch thick, broke with a pressure of 16 tons per square inch. Taking then, Sir William's own rule, if the tube had been $\frac{1}{4}$ inch thick instead of $\frac{1}{8}$ inch, it would have borne eight times as great a load, eight being the cube of two, for the doubled thickness. But eight times 16 tons equals 128 tons, and, dividing this by two, since there would be double the sectional area, it would seem by the above rule that the iron would bear in compression $\frac{128}{2} = 64$ tons per square inch of section; and yet, further on (p. 62), he says, that in calculating the strongest possible form not more than 16 tons per square inch must be reckoned on. This deduction seems to be perfectly inexplicable.

The writer has been told by a friend, a Cambridge wrangler, that Professor Clark Maxwell considered that both tensional and compressive fractures could be resolved into sheering fractures, and that broken iron might be assumed as coming asunder much as if two combs were stuck the one into the other. Fig. 3.

If this be the case, is it not evident that, say a dozen comb teeth must be (in tension) just about twelve times as strong as a single pair of comb teeth? Fig. 4. But, on the other hand, is it not equally clear that in compression the larger the number of such teeth the greater, relatively, must be the strength.

It is usual now-a-days to speak of molecules, and the swinging or rotation of one molecule round about another; perhaps such phraseology is neither more nor less accurate than the old style of speaking of nature as abhorring vacuum up to 32 feet. However, be that as it may, let it be supposed that these molecules are held together by some attractive force which is comparable to magnetic attraction or to magnetic repulsion. Now every schoolboy knows that he can more easily take the keeper off a magnet by sliding it than by pulling it straight off.

Take a series of molecules, Fig. 5, and let it be supposed that a fracture takes place along the line A B. It is perhaps not unreasonable to imagine that if the fracture is effected by pulling asunder, *i.e.*, by tension, that two individual molecules would separate in some such way as is indicated by the arrow, Fig. 6.

If, on the other hand, the fracture is effected by compression, that the molecules would follow (or strive to follow) the arrows in Fig. 7.

In either case the supposition is in accordance with what is often spoken of as the "angle of fracture."

But it will be noticed that in compression the molecule which strives to follow the arrows, Fig. 7, will come against, or come foul of, the molecules (shown by dotted circles) beyond, and that a series of such molecules will give each other a mutual and cumulatively-increasing support.

The deduction from the foregoing reasoning would seem to be that it is inaccurate to speak of the compressive strength of iron as being 16 tons (or any other number of tons) per square inch; that iron is probably like water, incompressible if absolutely confined; and that between the strength of $\frac{3}{4}$-inch bars and large masses there is an ever-varying measure of strength per square inch.

It might indeed be assumed that in practice it is very rare indeed to find iron absolutely crushed, and that in actual experience, with reasonably designed structures, the strength of wrought iron in compression is very

far above the conventional 16 tons per square inch. If this be admitted, it will become apparent how very necessary it is to study how to avoid the possibility of buckling.

This may be done in various ways. For example, in making wrought iron columns for sheer legs, a large amount of belly in the centre will be very efficacious. Also, it is probably expedient in compression to use the material in solid masses, rather than in the thinner plates which, on account of the greater facility they afford for riveting together, make them superior in tension.

In the writer's special branch, that of building steamers, the deductions above arrived at cut in two ways. If a ship is regarded as a girder, and it be estimated that a certain compressive stress will come on an iron deck, then the importance of "keelsoning" the deck beams, or introducing a series of longitudinal stiffeners, as suggested by Mr. William Denny, of Dumbarton, becomes at once apparent; while, on the other hand, if a much higher value can be given to the strength of wrought iron in compression than is usually assigned, then, perhaps, the strength which is commonly found at the gunwale, namely, in the stringer plate and angle, and in the shear strake, may be a full equivalent for the tensional strength of the other member of the girder.

In fact, one of the causes which led the author into this line of thought, was the observing of the way in which iron vessels break up when stranded, that is to say, almost always in tension, or, as far as his own observation went, always in tension.

A further deduction is, that if this suggestion is pushed to an extreme, and, in mathematical phrase, the strength of iron in compression supposed to be infinite, then, under that supposition, the neutral axis of a girder can no longer be considered as somewhere about the middle depth, but, on the contrary, must be taken as at the bottom of the girder, or say along the centre of the lower flange. This theory, which the writer enunciates with the greatest deference (if correct), would just about double the computed strength of simple girders, and would explain what has often seemed perplexing in estimating the strength of some ships whose scantlings have appeared to him insufficient, or barely sufficient, to withstand the strains to which they undoubtedly have been subjected.

It is, however, in bridge building that this subject acquires supreme importance, and the writer would gladly see a wider recognition of the compressive strength of wrought iron leading to an abandonment on the part of engineers of the system of girder bridges rather than see it lead to

the adoption (in girders) of a lower factor of safety. A girder bridge is open to many objections. In the first place, so long as the top and bottom members are made nearly equal, the one in compression, and the other in tension, there is twice as much material as would be necessary if the tension were taken by thrust against abutments. In a bowstring girder there is both the weight of the bow and the weight of the cord or string. If the span be considerable the principal load which the bridge has to bear is the bridge itself, so that an increase of weight adds in a geometrical ratio to the tensional stress. But perhaps a greater objection to the girder is that provision must be made for expansion and contraction, whereas an arch would rise and fall within itself. Nor is this all, the necessity of providing a certain amount of play for expansion leads to the girder being set down on the top of the piers instead of being bound in with them in the way that the haunches of a stone bridge spring from the abutments. There is little doubt that this was at least one cause of the giving way of the Tay Bridge.

In this immediate neighbourhood there are a great variety of types of bridges, and all of them are worthy of study. Over Dean Street is one of the noblest, if not the noblest, stone arch in the world. It was designed, the writer believes, by the present Engineer of the North-Eastern Railway, Mr. Thomas E. Harrison, under the late Robert Stephenson. At Sunderland is the fine cast iron arch, planned by Burdon, and afterwards stiffened by Stephenson, with arched wrought iron boxes to give lateral stability. Close alongside is the new Railway Bridge, a bowstring girder, but who designed it, or what considerations led to this type being adopted, the writer does not know. The High Level Bridge, by Stephenson, is *sui generis*, while the Redheugh Bridge will perhaps hereafter be criticised rather than imitated. At Scotswood is the extremely elegant Suspension Bridge, the work of the brothers Green, who also, the writer believes, designed the Ouseburn and Willington Viaducts, which were wooden arches on stone piers. These have since, with consummate skill, been altered into wrought iron arches, and they come more nearly to the ideal of a wrought iron bridge purely in compression than any other in the district, although the bridge crossing the Tyne at Wylam is, so far as its arch is concerned, a much more scientifically calculated and appropriate structure. This Wylam Bridge was designed by Mr. William Laws, of this town, who read a description of it before the Institution of Civil Engineers (Session 1878-79), in which he very moderately puts forth some, but perhaps not all, of the merits of his design. The principle on which the Wylam Bridge was constructed has also been adopted by Sir J. W.

Bazalgette in his design for the Tower Bridge, and in a design for a bridge over the Forth recently published in "Engineering" by Mr. Am Ende.

There are two other bridges in this district which, though hardly relevant to the subject of this paper, are well worthy of remark; the Swing Bridge, designed, the writer believes, by Mr. John F. Ure and Mr. Percy Westmacott, and the Byker Bridge, with its brick arches, the work of the late Mr. Hodgson.

The writer is desirous of inviting the members of this Institute to study these various types of bridges, to reflect on the respective cost of the foundations, piers, and abutments on the one hand, and of the superstructure on the other, and to consider how their ideas would be modified if once it were conceded that wrought iron properly arranged may be very much stronger in compression than in tension; and if, as it might seem, that wrought iron is a material which, when properly arranged, has a greater solidity of resistance than even granite, with a special elasticity of its own, it is not perhaps beyond a reasonable flight of fancy to imagine that rivers and ravines may be spanned by structures as architecturally beautiful as true in construction, which shall last to be the admiration of future ages.

Mr. Ross said, the subject of wrought iron in compression had not received that amount of consideration it deserved. Although he did not altogether agree with the writer in thinking that wrought iron in compression for either short or long columns could be made to stand as great a strain as in tension; yet he remembered an experiment which came before his own observation some time ago, which perfectly corroborated the statements of the writer of the paper—that a large area of iron was proportionately stronger in compression than a small area. Mr. Latham's experiments on riveting only gave for ordinary rivets a crushing strain of seven tons per square inch, beyond which there was perceptible indentation. With regard to the construction of boilers, in many cases the crushing strain seemed to be altogether neglected, although it was a very important element; for instance, in the ordinary way of fastening $\frac{3}{8}$-inch plates with $\frac{3}{4}$-inch rivets, $1\frac{3}{4}$-inch pitch, the portion in compression is ·25 square inches, the section through one rivet is ·44 square inches, while the area of plate in tension is ·375. According to Mr. Latham's experiment, the strength of the rivet would, therefore, be

insufficient, and this seemed to be borne out in practice, for by double riveting, and putting more metal in compression, the joint is increased in strength, although the area of plate in tension is unaltered. For long columns unquestionably wrought iron had great strength and advantages over cast iron. He thought the subject one of very great importance, and one deserving considerable discussion.

Mr. HAWTHORN said, he agreed with Mr. Richardson that the relative strength per square inch of section of a large and solid mass of iron in compression would considerably exceed that per square inch of a small mass, and that the former would resist more in compression than in tension—indeed, under some conditions, wrought iron would carry in compression 60 or 70 tons per square inch without injury. But in different structures, such as girders and pillars, it was not so much the iron that gave way under compression, as from the buckling which ensued from errors in construction, which destroyed the iron, not so much by crushing as by bending and tension, and he thought that the application of wrought iron in compression might be much more advantageously employed than at present, if all these circumstances were duly considered.

The CHAIRMAN thought they ought to pass a vote of thanks to Mr. Wigham Richardson for the very interesting paper he had sent to them; and perhaps it would be well to reserve any further discussion on the subject until Mr. Richardson himself could be present.

Mr. HEDLEY seconded the motion, which was carried unanimously.

Mr. JAMES I'ANSON read a paper, communicated by Professor A. Freire-Marreco, "On an Apparatus for Preventing Over-Winding," as follows :—

To illustrate Mr. Wigham Richardson's paper "On the Strength of Wrought Iron in compression".

FIG. 1.

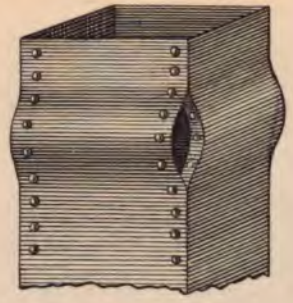


FIG 2

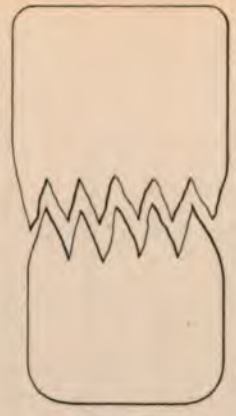


FIG. 3.

FIG. 4.

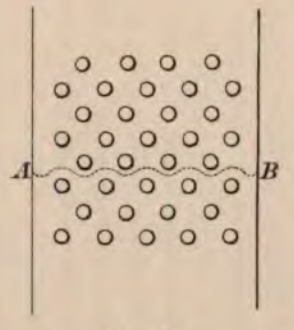


FIG. 5.

FIG. 6.

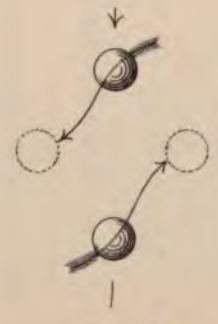


FIG. 7.

APPARATUS FOR THE PREVENTION OF OVERWINDING.

By JAMES I'ANSON.

Communicated by Professor A. Freire-Marreco, M.A.

THIS arrangement, in common with the various detaching hooks, etc., now in use, has for its object the prevention of accidents through overwinding; but it is sought in this case to accomplish the desired object in a different way and at an earlier stage than in the case of the hooks and contrivances commonly used.

The essential difference in the mode of procedure is this:—That whereas with the detaching hook the cage is wound up more or less violently against some appliance by which the connection between the cage and the rope is severed, the cage being left suspended independently of the rope; in the present case it is sought to strike at the root of the evil by arresting the motive power as soon as the cage has passed the point at which it ought to stop. This is accomplished by cutting the steam off the engine, and simultaneously applying a steam brake by an automatic arrangement which is brought into action by the cage itself as soon as it passes the proper stopping point. The way in which this is accomplished is shown in Plate XXXIII., in which A is a steam-brake cylinder, into which the steam is admitted by a piston-valve B. This piston-valve always has steam on its top side when the engine is working, so that the steam is constantly endeavouring to open the valve and find access to the brake cylinder. It is prevented from doing so, however, by the rod C and the crank D attached to the valve piston-rod, and held in position by the lock E, which passes through guides and through a slot in the end of the rod C, holding it in the position shown. The rod C is therefore always in tension, and the moment the lock E is lifted, by the cage striking the curved lever F, the rod is allowed to move in the direction of the arrow, and the steam at once gets access to the brake cylinder, at the same time turning the throttle-valve G, to the spindle of which the crank D is keyed.

The steam is thus cut off from the engine and admitted to the brake simultaneously, and the engine comes to rest before the cage can reach a position of danger.

It will be seen that if the engine be started the wrong way, the apparatus at once comes into operation, and stops it. After it has come into operation, the cage remains suspended until the steam is turned off at the boiler, and let out of the brake cylinder by a cock provided for that purpose, when it is lowered gradually down on to the keps. All that is then needed is to replace the lock, and until this is done the engine cannot be started, as the steam is cut off by the throttle valve G; this ensures the lock always being in the proper position when the engine is working.

The brake employed can either be the existing foot-brake to which the steam brake can be attached, or, preferably, an additional and separate one, leaving the existing foot-brake uninterfered with; or it may be arranged so that the steam-brake can be utilised in the ordinary working of the shaft, yet without destroying the self-acting character of the apparatus when the cage passes the proper point.

Since this paper was written, a description of a somewhat similar contrivance, which was brought before this Institute by Mr. J. Marley some thirteen years ago, has been brought to the author's notice. The principle involved is pretty much the same, though there are, naturally, differences in detail. The contrivance alluded to was provisionally protected by Mr. Marley, but the patent was not proceeded with. It is probable that the paper referred to may be in the recollection of members present.

Mr. I'ANSON said, that at present the subject was only in a theoretical stage, and, therefore, it might perhaps seem a little premature to bring it before the Institute, but he hoped shortly to be able to show the apparatus in operation, and would be very glad if any of the members of the Institute or anybody interested in the subject would come over to see it at the works at Darlington, where a model of about the scale of an inch to the foot is working under steam.

The CHAIRMAN said, perhaps it might be well to postpone any discussion upon this subject until they had heard another paper which was to be read at the next meeting, "On Overwinding," by Mr. Logan; and the papers would be better taken together than discussed separately. He therefore would at once propose a vote of thanks to Mr. I'Anson for his paper; this was seconded by Mr. HEDLEY, and carried unanimously.

To illustrate Mr James Parson's p
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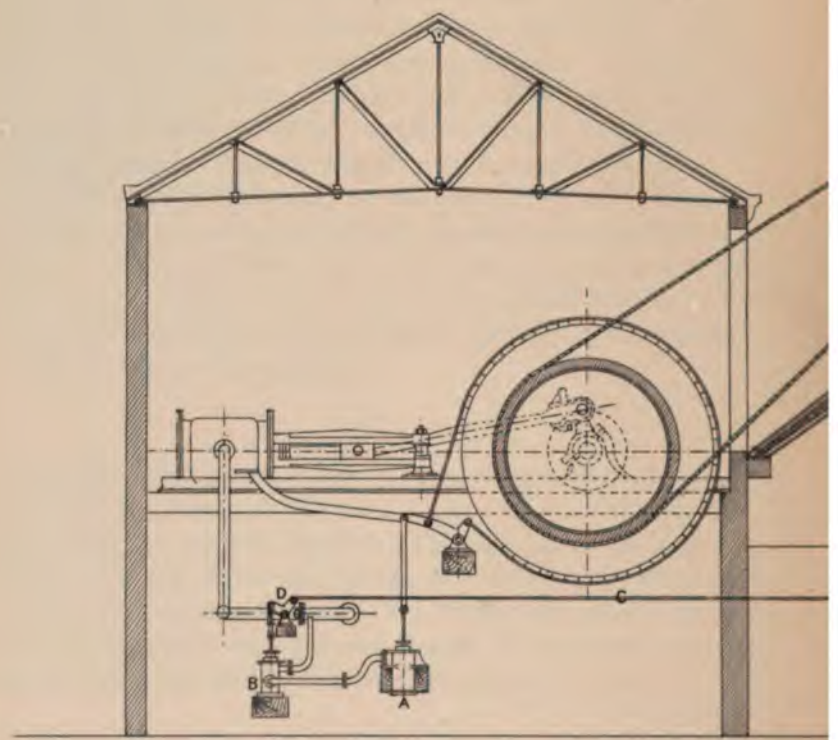
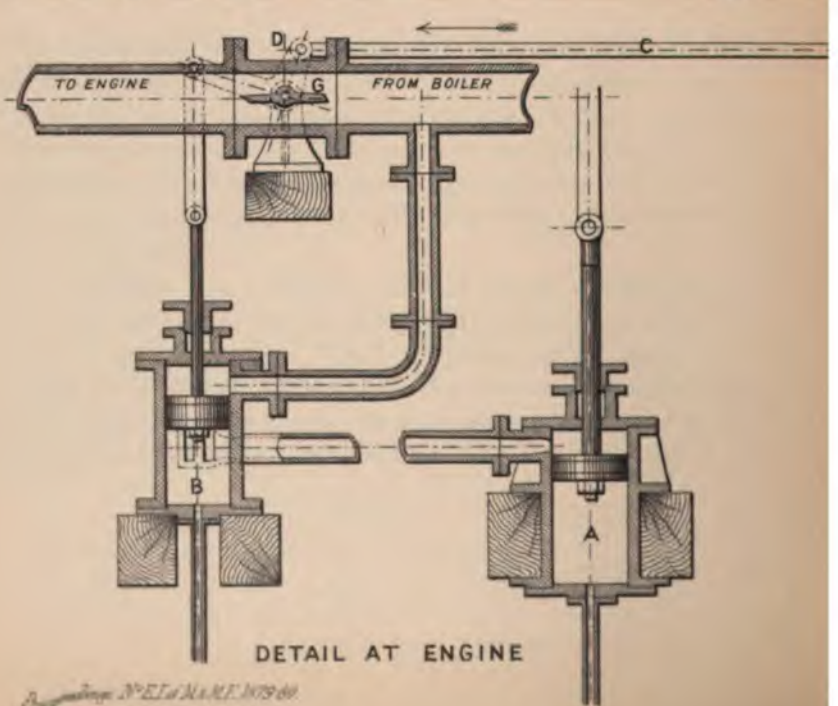
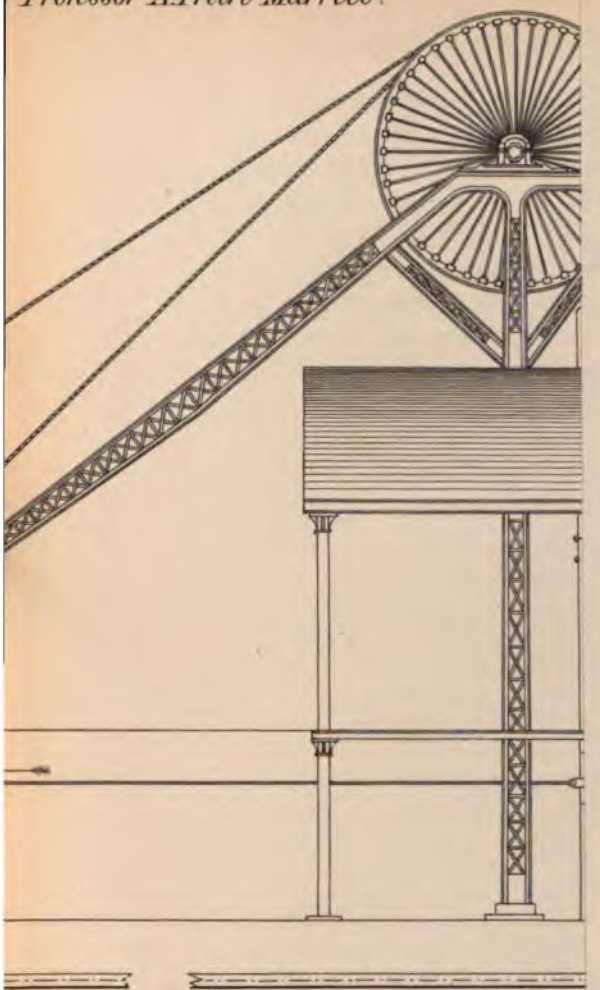




DETAIL AT ENGINE

Proceedings No. E.I. of M.M.E. 1879-80

m an "Apparatus for the prevention of over
Professor A. Freire Marreco.

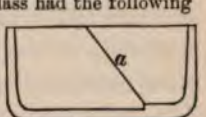


Steam Cylinder acting on brake lever
Cylinder for shutting throttle valve
and putting brake into action
Rod connecting the throttle valve G and
the piston of the cylinder B to the gear at
the heapstead by means of
Lever attached to throttle valve spindle
Wedge secured to one of the guides
at bank which when raised by
Allows the piston of the cylinder B
to fall and admit steam to the
brake cylinder A
Throttle valve

The CHAIRMAN said, the next business was to discuss the "Description of an instrument for ascertaining the inclination from the perpendicular of boreholes and the direction of such inclination," by Messrs. C. Ziethen Bunning and J. Kenneth Guthrie.

Mr. C. Z. BUNNING stated, that doubts having been expressed at the last meeting as to the possibility of any borehole being so much as 47 degrees out of the perpendicular, he had written to several gentlemen abroad who had used the instrument, and to others both in England and abroad, who had had extensive experience in boring. He must admit that the opinions received varied, but where facts had been obtained they seemed to warrant the belief that such an amount of deviation and even a greater amount had been experienced. With regard to the peculiar borehole (Gustav Adolph) Mr. G. Nolten writes:—

"As regards the inclination of 47 degrees from the perpendicular, it is to me quite possible. When doubting of its possibility you perhaps are thinking of diamond boring machines which are used in England. Such a boring machine was not used, but one consisting of strong four-sided iron rods of about 2 inches square, to the end of which was fastened the boring tool. The whole borehole was lined with 6-inch tubes on account of the softness of the strata, the hole not having reached the coal-measures. Mr. Morian, in Neumühl, asked me to place the instrument in the Gustav Adolph borehole, and I found the inclination as Mr. Selbach has stated it. Mr. Morian told me before I experimented that the borehole had been stopped since December, 1875, and that the 6-inch iron tubes could not be driven any further, and that in consequence 4-inch tubes were decided to be put in in order to proceed with the boring, but that before they expended further money they should like to know in what direction the borehole was going, although the former boremaster had asserted that it was perfectly perpendicular. The instrument was lowered purposely to the greatest depth, namely, 750 feet, and left there three-quarters of an hour, although half-an-hour would have sufficed for a distinct etching, and I was present during the time when the instrument was lowered and when being drawn up to see that no pause occurred. The etching proved so strong that one could feel it with the finger in the glass. The etching on the glass had the following form, the level of the liquid being shown by the line *a* in the woodcut, which proved that a portion of the acid was lying next the India-rubber plate covering the glass. After cleansing the glass, clear water was poured in a lesser quantity than the acid which had been in before. The glass was again placed in the instrument with the lid, and was held in such position that the surface of the water was parallel to the acid mark. By so doing the position of the instrument in the borehole was reproduced, and this position was found to be 47 degrees from the perpendicular. With such a great inclination it was of no moment to arrive at the inclination more accurately, for such as it was, it was entirely impossible to proceed with the boring.



Mr. C. Selbach, of Oberhausen, writes:—

In answer to your letter of the 3rd inst., I beg to reply that I have endeavoured in vain to get sufficient information as regards the magnetism in iron tubes. I think that

if a magnetic needle is placed in a magnetic iron tube, that the electric magnetic currents will strive to run parallel with the needle, so that in case the iron tubes are in a vertical position the inclination of the needle will become greater. I have conducted a galvanic current round a magnetic needle in a horizontal position and the result confirms my theory.

In answer to another of your questions I stated that I have, with the inventor, Mr. Nolten, experimented with the instrument in the borehole Gustav Adolf, near Dienslachen. The experiments lasted six hours, and all present were entirely satisfied with the correctness of the results. Regarding the 47 degrees inclination of the borehole, Mr. Nolten himself measured it: I have seen the glass with the etched marks, and am fully convinced of the correctness of the measurement as Mr. Nolten is very particular and would certainly not be mistaken. It is very likely that boring with a turning machine will produce boreholes very much out of the perpendicular, which would not happen by percussion boring. Mr. Kiepel, manager of the Oberhausen Colliery, told me yesterday that he has himself observed such inclination, namely, in the sinking of a shaft where a borehole had been previously put down. The shaft reached the seam of coal 15 fathoms sooner than the borehole, which very soon entirely disappeared from the shaft. This would, if the seam were perfectly horizontal and no fault had intervened, give an *inclination* from the perpendicular of about 36 degrees. Mr. Kiepel related to me cases in which the inclination reached greater angles. It must be considered that by turning boring machines, an inclination, however small at first, must constantly increase, and the borerods will form a curve gradually getting more and more out of the perpendicular.

Professor LEBOUR thought that in speaking of boreholes which were more or less out of the perpendicular it was generally assumed that the deviation was all in one plane. Since reading the paper he had written to Belgium, where a good many experiments had been made during the last fifty years on boreholes which were out of the vertical position, and there they seemed to regard it as a regular rule that such holes follow a somewhat spiral line very much like the rifling of a gun. He thought that probably this information would help them in some degree to understand some of the deviations of boreholes, but, of course, would not explain any so great as those mentioned in the paper, which he thought were hardly ever met with in practice. Of course the fact that the borehole was 75 fathoms deep while the shaft was only 60 did not necessarily prove that the former made an angle of 36 degrees with the vertical: there might have been a fault intervening, or the seam might have been much inclined and the borehole gone to the dip. If Mr. Bunning could tell them how they were working there, and it was proved that the woodcut really represented the fact as to extreme deviation, it would be admitted at once.

The CHAIRMAN said, that it was much more easy to go out of the perpendicular in soft strata than in hard, but even in the latter it was

very easy to do so. He knew a case where, during the sinking of a shaft 8 feet diameter, a borehole was put down in the centre of the bottom, for the purpose of carrying off the water to a lower level, but, by the time they had got 12 fathoms the hole had gone into the sides of the shaft, and it was no longer useful for getting the water away. The hole was bored in very hard stuff, and he could only account for it by supposing that the men were not very particular in setting away the rods at the beginning, and thus a bias was given at starting, which would probably be gradually increased till it reached an angle of 8 or 10 degrees, and at the finish it was probable that a greater angle might occur, although one could hardly believe it would reach 47 degrees; but still Mr. Bunning had brought the thing before them so carefully that it must be considered fairly worthy of credit. If the borerods pressed into some buried soft strata or into the angle of a fault, for instance, they might take a bias at a very great angle.

A MEMBER said, the hole might have gradually departed from the plumb line, and the deviation might have gone on in some progressive rate till just at the bottom of the hole it reached 47 degrees. The hole the Chairman referred to was 4 feet out in 12 fathoms. If it had been proved down to 60 fathoms there was no knowing how far out it might have been.

Professor LEBOUR said, that although it might be actually proved that a borehole deviated to the extent of 47 degrees, it was not probable theoretically.

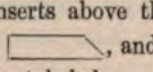
Mr. WEEKS stated that in the absence of precise information as to the inclination of the strata and the presence of faults, it would be as well at present not to come to any conclusion on the statements made by Mr. Selbach in his letter.

Mr. GEORGE MAY said, as the hole had been actually bored in practice, Mr. Bunning might get more information by writing to ask if they ever found the borehole in the seam, and the precise circumstances under which it was found, and if the distance at which it was found from the bottom of the shaft agreed with the statement given of the inclination of the hole.

Mr. C. Z. BUNNING said, that the hole had been found in the seam, but he did not know under what circumstances.

Mr. HUMBLE, Staveley, said, that in a case which he knew, to the west of Blaydon, there was an old shaft sunk to the stone-coal seam and partly filled up, and to relieve the water a borehole was put down with the intention of boring through from the stone-coal into the five-quarter

seam. After boring a longer distance than was necessary to reach the five-quarter, the hole was given up. When they got to the stone-coal seam by driving up from the five-quarter, they found the rods had been diverted into an old heading in the stone-coal, and had passed along some ten or twelve yards; and it is probable that some of the rods are there to this day. The seam would be at an angle of 90 degrees with the old shaft.

Mr. AITKEN said, he had never experienced results so startling as that just related, although he had often seen greater deviations than that mentioned by the Chairman. For instance, he had known a borehole go out of a 12 feet shaft in 10 fathoms. If a borer has passed through a coal or ironstone seam, and desires to re-bore the seam so as to get another sample, he inserts above the seam a bar of iron or steel with a point shaped thus,  , and having secured it in its place, proceeds to re-bore the metals below. No inconvenience arises from the bore going off at this angle.

The CHAIRMAN, in summing up the discussion, said, they must come to the conclusion that when putting down boreholes on which much was depending, it would be very desirable to use the instrument described by Mr. Bunning.

The CHAIRMAN—The next business was the discussion of Mr. Henry Aitken's paper "On the Extraction of Oil and Ammoniacal Liquors in Coking Coal in Ovens." Perhaps Mr. Aitken had something further to say before they commenced the discussion.

Mr. H. AITKEN said, that in conformity with his promise he now supplied the analysis of the coal, the coke from which was exhibited at last meeting:—

SAMPLE MARKED "COAL FROM JAWCRAIG, NORTH SIDE OF DYKE," MARCH 29TH, 1880.

Volatile matters	Gas, tar, etc.	33·94	38·10
	Sulphur	·16	
	Water @ 212° Fahr. ...	4·00	
Coke	Fixed carbon	58·38	61·90
	Sulphur	·12	
	Ash	3·40	
			100·00

COMPOSITION OF 100 PARTS OF THE COKE.

Fixed carbon	94·31
Sulphur...	·19
Ash	5·50
Coke per ton of coal in pounds	1,386½
	Cwt. Qrs. Lbs.
Coke „ „ cwts., qrs., lbs.	12 1 14
Specific gravity of coal	1,282
Weight of a cubic foot	80¼ lbs.

(Signed) ROBT. MCALLEY.

It may not be out of place to observe that no analysis of coal gives any idea as to whether it is a coking coal or not, and he did not know any method of analyzing that would show this. The only plan seems to be to test whether it does coke. These remarks apply to coals containing over 20 per cent. of volatile matter.

Since the last meeting a gas pump has been put on as an exhauster to draw the gases from the bottom of the oven in place of the steam jet, and a bubble-washer has been added to assist in the extraction of the ammonia. A good many charges of coal of four tons four cwts. have been worked off (oven 10 feet 3 inches dia.) in from 32 to 36 hours, the yield of dry coke being 65·77 per cent., that of oil about 8½ gallons per ton of coal, specific gravity 1,000, and the yield of ammoniacal water about 20 gallons of water, two Twaddel. The coke made was, no doubt owing to the high heat, in somewhat smaller pieces, but it was harder coke than any produced from ground or small coal. The analysis of the coal used is as follows:—

ANALYSIS OF BINNIEHILL SPLINT COAL, BY ROBERT MCALLEY, CHEMIST, FALKIRK, 27TH OCTOBER, 1879.

Volatile matters	28·83
Fixed carbon	64·20
Ash	4·50
Sulphur...	·27
Moisture at 212° Fahr.	2·20
	100·00
Heating power	8·98
Volatile matters present	31·17
Coke per cent.	68·83
Coke per ton in pounds	1,541¾ lbs.
	Cwt. Qrs. Lbs.
Coke „ cwts., qrs., lbs.	13 3 2
Ash per cent. of coke	6·53

The yield of coke here given is 68·83 per cent. The usual yield as per previous analyses of this coal is 66·52 per cent.

In coking this coal in the ordinary 10 feet 3 inch diameter bee-hive ovens the usual time taken with a three tons four cwts. charge is 80 hours. The time taken with this oven with charges of four tons four cwts. was from 32 to 36 hours, thus doing the work in one-third the time taken by the ordinary oven. No charges have as yet been worked off with only three tons four cwts., but it will not take much more than 24 hours to complete the coking of such a charge.

Mr. Aitken said further in reply to Mr. Hedley and the Chairman, that the coke was harder by his process than by the ordinary ovens, and retained its silvery appearance. All that was required was a fan or pump to exhaust the gases, and condensers to cool them to the temperature of the atmosphere. The ordinary arrangements in use at gas works to absorb the ammonia would do, and it could, if made large enough, be applied to a row of ovens. He thought the advantage of the arrangement was, that by its use, coke could be made that was suitable for all purposes, and at the same time the whole of the oil or tar ammonia would be separated, whereas in all the systems of coking that he had ever seen, by which it was attempted to get either ammonia or tar during the process of coking, the coke had been deteriorated and rendered unfit for sale.

Mr. D. P. Morison asked Mr. Aitken if he could give any idea of the saving per ton of coke effected by his process, as this would facilitate the consideration of the subject on economical grounds. He could easily understand that if the ammonia and other products of distillation could be taken off and utilized, it must be a matter of very great moment indeed, provided it was not accompanied by too expensive machinery, and if Mr. Aitken could give them any information on that subject it would help them to consider the question usefully.

Mr. Aitken said, he was hardly in a position to answer Mr. Morison, but there was another point which possibly he should have attended to before, and that was, that in making the coke and taking off the gases, they largely increased the yield, and invariably obtained within two or three per cent. of the theoretical result. This was not done with any beehive oven that he had ever seen. The value of the oil obtained was over threepence a gallon, and as they had been getting eight to nine gallons per ton of coke, that was about two shillings a ton gained in this way alone, and they had the value of the ammoniacal water over this.

Mr. Breckon said, that still left them rather in doubt as to the gain per ton of coke, after the expense and every other disadvantage had been

taken into account. Now, if a gain of something like a shilling a ton in the use of this arrangement could be obtained without deteriorating the quality of the coke, that would be at once a strong incentive to take up the invention and proceed with it as vigorously as possible. With regard to the percentage of coke obtained (between 53 and 54 per cent.), he thought there were gentlemen present who were aware that coke ovens had been in use for many years in the county of Durham that had constantly yielded from 60 to 66 per cent. of good marketable coke, therefore the system here presented did not pretend to gain much in this respect, but they had a great deal to look forward to with regard to the utilization of the products. It was a very useful and practical idea in connection with the new process to take back the gases and put them into the dome of the oven to assist the necessary combustion, in order to produce an excellent coke. If that could be accomplished, and the ammonia and oils utilized, he could easily see that that was a matter of very great moment indeed to coke manufacturers in the county of Durham.

Mr. Aitken asked permission to point out to Mr. Breckon that he had evidently overlooked the fact that whereas Durham coal yields (in a retort) somewhere between 70 and 75 per cent. of coke or thereabouts, Scotch coal does not yield more than from 50 to 65 per cent. Now, he could obtain with the patent oven within 2 to 3 per cent. of the yield got by a retort, whereas the ordinary ovens did not reach it within 10 or 15 per cent.

Mr. D. P. Morison said there was one other point which should be very carefully looked into, that was, the time occupied in burning. If the reduction of the time in burning was, first from 80 hours to 62, and then again from 62 to 32, he thought it followed that there must be a very considerable economy indeed in that respect, in addition to the assumed value of the products obtained by distillation.

Mr. Aitken said 32 hours was the very shortest time they had accomplished it in. In 36 hours they had done it several times; and at 32 hours the temperature was (as was naturally to be expected from the rapidity with which the work was done) intensely high, and he thought that for this reason it would be better to fix the process at 60 hours.

The following figures will show how the profit and loss account would stand in working such ovens as have been described. These figures are not all from actual estimates, but are approximations as near as can be arrived at, without actually taking in estimates for the work to be done. The estimate will be based upon the expense necessary for the erection of 50 ovens on the new plan in the County of Durham.

50 ovens, 11 feet diameter (£55 per oven), with railways, blowing engine, boilers, buildings, air heaters, pipes, exhauster, condensers, scrubbers, etc., will cost say £8,000 erected, 15 per cent. upon this outlay ...	£1,200 0 0
Extra attendance per annum	120 0 0
Oil, furnishings, etc.	100 0 0
	£1,420 0 0

These 50 ovens will coke 3 tons of coal each per 24 hours, or 150 tons per day, and they will produce 9 gallons of oil per ton, 1,350 gallons for which 3d. per gallon, without barrels, have been offered, taking however, for safety 2½d. per gallon.

This gives	£14 1 3
The ammonia water is probably worth 1s. 3d. to 1s. 6d. per ton of coal coked, but say 1s. per ton	7 10 0
Together	£21 11 3
Which, multiplied by say 280 working days in the year, gives	6,037 10 0
To this has to be added the increased yield of coke which is estimated at from 8 per cent. to 15 per cent., say however, that 70 per cent. is got in place of 65 per cent., the extra coke thus got will be 2,100 tons at 10s. per ton	1,050 0 0
	£7,087 10 0

It is to be kept in mind that ovens worked so rapidly, and at such a high temperature will require more repair, but the above would leave ample margin.

Further, the only coals which have been used are Scotch, other coals would require to be tested before adopting the process elsewhere. It is also to be kept in view that for the production of the amount of coke which the above 50 ovens would make, there would be required about 125 ordinary ovens. These would cost at £55 each, £6,875, so that the extra outlay for the new ovens, with all the necessary appliances, would only be £1,200 more.

The CHAIRMAN did not think there was anything more to be said on the subject. He begged to propose a vote of thanks to Mr. Aitken for

having kindly come all the way from Falkirk to resume the discussion of his paper. He felt sure that if such results as Mr. Aitken stated had been attained with his experiments in Scotland, and it could be carried out successfully in the same way here, it would speedily be applied.

Mr. BRECKON seconded the resolution, which was unanimously carried, and the meeting terminated.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, MAY 1ST, 1880, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

G. C. GREENWELL, ESQ., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting and reported the proceedings of the Council.

The following paper "On Safety-Hooks," by Mr. WILLIAM LOGAN, was then read:—

SAFETY-HOOKS.

By WILLIAM LOGAN.

In the month of December last year a letter was addressed by the various Inspectors of Mines, at the instigation of Her Majesty's Secretary of State, to every manager of mines, drawing their "attention to the inventions for disconnecting in case of overwinding, such as are now in successful use at many collieries," and expressing a hope that, "if such appliances are not already attached where they are applicable at your mines, you will kindly give the subject your earnest consideration with the view of having them applied."

From this it would appear that the Inspectors of Mines are now unanimous in recommending the adoption of safety-hooks, and it may possibly be that in a short time they will ask for means to enforce their adoption. It is in view of this that the writer has been induced to prepare a paper with the hope of elucidating the opinion of the members of this Institute on the subject.

The Inspectors of Mines have not always been unanimous on the subject, as the late Mr. John Hedley, in his report for 1863, says:—"They cause a false feeling of security, and the ropes, chains, and other portions of the winding tackle are neglected through the reliance placed on the so-called 'safety-apparatus.'" And Mr. Ralph Moore, in his report for 1878, referring to an accident from overwinding, says:—"Notwithstanding this accident, I am not prepared to advise the adoption of any of the various so-called 'safety-hooks.'"

The other Inspectors, when commenting on accidents from overwinding, have, however, from time to time recommended their adoption.

For over twenty years safety-hooks in some form or other have been before the public, and every inventor of a safety-hook claims that by the use of his hook lives have been saved; but as no reliable data exist as to the number of lives saved except that published by the inventors themselves, and as such data must be taken *cum grano salis*, the writer refrains from giving the numbers.

There are also no accurate data as to the number of overwinds that

take place, for although an act of overwinding may cause great destruction of property, it is only when an accident occurs fatal to human life that the fact is recorded, and, up to the end of 1872, only at those mines which were under Government inspection. Since 1872 the field of inspection has been enlarged, and there is now a full and reliable record. The Mines Inspectors' reports, beginning at 1855, have been carefully examined, and they show the following number of lives lost by overwinding:—

	No. of Lives Lost.
1855 to 1859 inclusive	47
1860 to 1864 „	35
1865 to 1869 „	36
1870 to 1874 „	28
1875 to 1879 „	32
Total	178

And these may be classified as follows:—

Causes.	No. of Lives Lost.	Percentage.
1. Defect of engine, throttle valve sticking, crank pin breaking, insufficient brake power, etc.... ...	13	7·30
2. Defect of indicator not showing position of load ...	11	6·18
3. Attention of engineman withdrawn from engine by persons in engine-house	10	5·62
4. Incompetent engineman	6	3·37
5. Engine reversed and cage drawn wrong way ...	22	12·36
6. Fault of engineman omitting to stop load at proper place	110	61·80
7. Collapse of safety-hook, or failing to act properly	4	2·25
8. Cage lowered into sump and occupants drowned ...	2	1·12
	178	100·00

Thus, omitting No. 8, 98·88 per cent. of the lives lost would have been saved by the adoption of efficient safety-hooks and other appliances.

Previous to the Mines Inspection Act of 1872, coal was the only mineral of which an accurate account was kept, and the writer has only been able to obtain reliable returns commencing in 1864, and these show the following results:—

	Tons of Coals Worked.	Lives Lost by Causes previously Enumerated.
From 1864 to 1872 inclusive	966,119,982	60

Or one life lost for every 16,109,999 tons of coal worked.

The details from 1872 are much more comprehensive, and may be given fully as follows, embracing as they do the whole of the United Kingdom :—

Year.	Mineral Raised.	Persons Employed Underground.	Lives Lost by Causes previously Enumerated.
	Tons.		
1873	143,041,246	407,808	5
1874	140,713,832	428,611	7
1875	147,700,313	427,017	4
1876	148,989,385	409,229	3
1877	147,846,260	395,025	4
1878	154,798,138	382,979	14
1879	145,366,369	385,179	7
Totals	1,028,455,543	2,835,848	44

So that from the causes previously enumerated, there is one life lost for every 23,373,989 tons of mineral raised, and one life lost for every 64,451 persons employed.

It will, of course, occur to every one that a portion of this mineral is not raised by vertical shafts, but is produced by adits, and that the tons of mineral raised per life lost is greater than the actual quantity; but it is also known that the quantity of mineral raised otherwise than by vertical shafts is small compared with the whole quantity, and the writer ventures to state the approximate actual quantity as one life lost for every 20,000,000 tons of mineral raised during the last seven years.

The number of windings that take place to lower and raise the persons employed underground can also only be arrived at approximately, and the writer assumes an average of six persons descending and ascending in one cage (and this he considers a high average), so as to allow for the number of persons who do not descend or ascend in cages where the mineral is not got by vertical shafts, this gives 64,451 persons divided by six, and this doubled for the descent and ascent, and multiplied by 250 working days a year, makes one life lost for about every 5,500,000 windings of persons employed underground during the last seven years.

For the purpose of preventing the loss of life, destruction of property, stoppage of work, etc., numerous inventions have been brought to the notice of the public, and, for the purpose of inviting discussion on the several appliances, the writer will proceed to describe them in detail.

BRYHAM'S HOOK.

This hook has now been in use for upwards of twenty years, and was the invention of Mr. John Bryham, of Rosebridge Colliery, Wigan. It belongs to the class of simple detaching hooks, and its action will be seen in Plate XXXIV. (Figs. 1, 2, and 3), which represents the hook in front and side views; A A represent two wrought iron plates, forged with slot B, to receive the shackle C, as shown in Fig. 2, to which is attached the cage; D is a wrought iron disengaging plate forged with the slot E, as shown in dotted lines, and fixed between the plates A A; it is kept in its working position by a small brass pin F; G is a wrought iron plate of suitable size, fixed in the head gear framing, with the rope working through it, and consequently when the cage is raised too high, the hook being attached to the rope is drawn through a circular hole in the plate of such a diameter as not to allow of the hook passing through it without first shearing the brass pin F, pressing in the plate D, and removing the shackle with its load from its working position into the slot B, and thus disconnecting it. To prevent the cage from falling down the shaft after detachment, catches are fixed in the guide rods and so arranged that the cage in ascending raises the catches, and immediately it has passed them they fall into their original position and receive the cage after detachment from the rope and hook.

KNOWLES'S HOOK:

The invention of Mr. Israel Knowles, of the Ince Hall Collieries, is also a simple detaching hook, and its action will be seen by reference to Plate XXXV. Fig. 1 is a front view, and Fig. 2 a side view of the hook when attached to the rope and cage; Fig. 3, shows the hook after detachment has taken place. As in Bryham's arrangement a wrought iron plate with a circular hole is fixed to beams in the head gear to cause detachment.

The rope is attached to the pin A; B B are wrought iron plates forged with a slot C; D is a wrought iron disengaging plate kept in position by the copper pin E, and disengagement is effected by the wing of the plate D being unable to pass through the circular hole of the plate fixed in the head gear without shearing the copper pin E, forcing the pin F into the

slot C, and so releasing the rope. Safety-catches or keeps are placed in the guide rods to receive the cage after detachment.

Having described two hooks, which are simple detaching hooks, the writer will now proceed to describe hooks which aim at not only being detaching hooks but which are so constructed that after the rope is released they suspend the cage without the aid of catches or keeps.

KING'S HOOK:

The invention of Mr. King, of Pinxton, Derbyshire. Plate XXXVI., Fig. 1 and 2 represent a front and a side view of the hook in working order; it is self-detaching and self-suspending, not only detaching the rope but suspending itself at the moment of detachment with the cage attached. Fig. 3 represents the hook when detached and suspended on the catch plate, which is securely bolted on to two strong timber or girder beams in the head gear. The catch plate has a circular hole through which the rope runs.

The hook consists of a framework of two outer plates, A A, between which are fixed two inner plates, B B, so as to oscillate about a strong pin C, which goes completely through all the plates; the four plates being for the greater part of their length of exactly the same width.

The winding rope is attached to the top shackle F, and the cage chains to the bottom shackle J at the lower end of frame A A, which is made of uniform width throughout, with the exception of the projections K K at the bottom, so that it easily fits, and can freely enter the ring in the catch plate, but not pass quite through it.

Each of the plates, B B, is a fac-simile of the other, having the top part G G shaped as a hook, which entirely overlaps and takes a firm hold of the shackle pin L, the lower part being feathered out on one side D D. It will thus be seen that when set in the framework in opposite directions on the pin C and shut together, they form a double hook at the top, and the pin has no tendency to slip out owing to the slight curve of each jaw.

As an additional safeguard a copper pin H, three-eighths of an inch diameter, goes through all the four plates.

In ordinary work the weight of the load carried by the hook is communicated to the rope by the bottom shackle J and pin P through the outer plates or framework A A, the pin C and the hooks G G of the inner plates B B.

In case of overwinding the hook passes up through the circular hole of the catch plate fixed in the head gear; the two wings D D of the inside

plates which project beyond the framework are forced inwards by coming in contact with the catch plate O, the pin H being sheared into four parts, and the jaws at the top gradually separated from each other until the shackle pin L can escape between the inner points. The rest of the motion is assisted by the escape of the pin of the rope shackle between the inclined noses of the jaws G G, while the hook and load are left hanging on the catch plate supported by the two catches E E, which were forced outside the framework by the same action which released the rope.

KING AND HUMBLE'S HOOK.

King's hook, as improved by Mr. Stephen Humble, of Derby. This hook is represented by Plate XXXVII., Figs. 1, 2, and 3, and in construction and action is almost identical with King's hook previously described, except in the details which will be fully noticed.

Fig. 1 represents a front, and Fig. 2 a side view of the hook as in actual working order. It is a self-detaching and self-suspending hook.

Fig. 3 represents it when detached and suspended on the catch plate.

The hook consists of four plates, viz :—Two outer A A and two inner D D, which oscillate about a strong pin J.

The difference between this hook and the one previously described is, that the projecting wings are dispensed with, and a collar B is substituted, which goes completely round the plates, and is held in position by two copper pins, N N. In the collar is placed a loose pin E, which passes completely through both the collar B and the four plates of the hook. In each of the outer plates there is a vertical slot I, and in the inner plates grooved slots F F.

In ordinary work the weight of the load carried by the hook is communicated to the rope by the bottom shackle O, pin P, side straps Q, the centre pin J, and the hooks K K of the inner plates D D.

When an overwind occurs, the hook passes into the ring or catch plate, and the collar B in which is the pin E, comes in contact with the catch plate C, and as the hook is still drawn upwards, the natural result is that the collar is pressed down, shearing the copper pins N N; and the inside plates D D, being actuated by the pin E in slots F F, are forced open, releasing the rope shackle, and the hook with its load is left suspended on the catch plate, by the two catches M M of the inside plates which are sufficiently strong to hold the load attached to the hook.

In King's hook (Plate XXXVI.) it will be noticed there is just sufficient space for the catch plate to rest between the wings D D, and catches E E, and in King and Humble's hook between the collar B and catches

M M; consequently it is believed to be impossible for either hook to detach itself until drawn sufficiently far through the circular hole in the catch plate, and this is effected either by a quick or slow overwind.

Another point of importance is that the hooks being overhung, that is, the pins C (Plate XXXVI.) and J (Plate XXXVII.) being above the catches E E and M M (the faces of which when first emerging from the frame are inclined upwards towards the centre of the hook) the moment the catches gain the slightest hold upon the catch plate, the safe suspension is practically accomplished; for the weight of the load will then tend to force the catches out to their full extent, and there is not any chance of the hooks again closing. Until this point in the action of the hook is reached, their tendency is not to open, but to keep shut, on account of the gradual curve in the inner plates clutching the rope shackle pin L.

The other points claimed in these hooks are the gradual and simple nature of their motion, and the great simplicity both of the hooks and catch plates, while the catching points E E and M M, owing to their vertical depth are exceedingly strong.

ORMEROD'S HOOK:

The invention of Mr. Edward Ormerod, of Manchester, first patented in 1867, but since improved by the lengthening of the middle plate to facilitate re-attachment.

This hook as will be seen by Plate XXXVIII. also belongs to the class of plate hooks, and the inventor claims for it that the strain is not transmitted from one plate to another, causing a shearing strain on the pins; but if perfectly made, the strain is through all the plates from end to end.

It is also a detaching and suspending hook, and instead of using a catch plate on which to support the load after detachment takes place, a cylinder is used.

Fig. 1 is a front view of the hook. Fig. 2 is a side view, and Fig. 3 represents the position it assumes after detachment of the rope and suspension of the load with the hook on the cylinder.

It will be seen that the hook is formed of three plates, and when in ordinary use, as in Fig 1, is wider at the bottom than the top; but in the event of overwinding the hook is drawn into the bell-mouthed cylinder F F (Fig 3), and the wide parts of the hook at H H, coming in contact with the inner side of the cylinder, are pressed inward, while the top parts are pressed outward, allowing the projections to catch over the top

of the cylinder. At the same time the rope shackle A is forced out of its seat and allowed to go free, while the bottom shackle B drops into the slot D and locks the hook firmly in its position.

To prevent the plates being disarranged in ordinary working, a copper pin P is inserted through the plates, which keeps them in position and is sheared through as the hook passes into the cylinder.

To facilitate the lowering of the cage after detachment, the shackle A is attached to the ear of the middle plate as shown in Fig. 4. On removing the pin C and slightly winding the rope, the middle plate—having a slotted hole for the pin—is elevated into the position shown, and allows the hook to pass down through the cylinder; the cage is safely lowered on to the keeps and re-attachment takes place.

THE GRANGE HOOK.

This hook is of recent construction, and is being manufactured by the Grange Iron Company, Durham. It consists of three plates planed true on the inner sides (Plate XXXIX.); the middle plate A to which the lifting shackle B is attached, has two projections to prevent the hook being drawn through the plate, and the distance between the projections and those on the two outer plates is the least possible, so as to give a minimum amount of fall when detached. The three plates are held together by the centre bolt C, to the projecting ends of which a double hook or claw is attached to lift the hook and cage after detachment, and refix the rope shackle D. The two outer plates are held in position by the copper rivet E.

Figs. 1, 2, and 3, represent a seven ton hook. Fig. 1 shows the hook ready for detaching, and Fig. 3 after detachment. The bolt F during detachment drops down into a groove and prevents the plates re-adjusting themselves by the shock, and falling through the retaining plate G.

WALKER'S HOOK.

This hook belongs to a different class to those previously described, and is also detaching and suspending; it was invented by Mr. William Walker, of Saltburn-by-the-Sea, and has been in use since 1871.

Plate XL., Fig. 1, represents the hook closed and attached to the rope, the cage being attached to the bottom link B.

Fig. 2 shows the hook open and anchored on the cylinder C after detachment has taken place.

The lifting rope is attached to the shackle A, and the load to the connecting link B.

The supporting ring C (through which the rope is constantly working) is a fixture in a baulk of timber, or iron girder, at the pit top.

The hook consists of a pair of jaws, D D, working on a centre pin, E, in such a manner that the weight of the load has a tendency to open the upper limbs, which clip the strong centre pin of the shackle A. The upper limbs are formed externally with jaw hooks, F F. The jaws are kept together, and made to retain the shackle pin by means of the clamp H, which is held in position by the copper pins I I.

In case of overwinding, the jaw hooks (held together by the clamp) pass freely into the ring C, but the projections K K of the clamp coming into contact with the bottom flange of the ring, hold the clamp stationary, while the jaws are being pulled through, the result being that the pins I I are sheared off, and the jaw hooks released from the restraint of the clamp. The internal diameter of the ring being the same as the width across the jaw hooks, F F, the rope remains secure until the jaw hooks reach the top of the ring, when, by the action of the weight of the load, they are forced open, and so hook on to the top of the supporting ring C, as shown, the rope passing harmlessly over the pulley.

The recess O, in the ring C, is intended to meet an imaginary case that experiment shows to be almost impossible, namely, that if the engine is reversed after the pins I I are cut, and before the hooks reach the top of the ring, the jaws will then hook into the recess, and the load remain suspended in perfect safety.

It will be observed that the upper edge of the ring C is curved to match the sweep of the jaw hooks when opening. By this arrangement all shock is avoided.

The size of the pin of the shackle A is so proportioned that, in leaving the jaw hooks, they are opened by it on to the full hold of the ring, and the clamp H at the same time coming down on to the lower limbs, locks the hook securely on to the ring.

WALKER'S IMPROVED HOOK.

Mr. Walker has recently improved his hook in the manner shown in Figs. 1 and 2, Plate XLI.

Instead of the cylinder, a catch plate A is substituted, and four copper pins B B, B′ B′ are used. A square hole is cut in the clamp C, and the clamp kept in position by a tongue and the two upper copper pins B B, and detachment cannot take place until not only the two upper copper pins B B are sheared, but also the two lower copper pins B′ B′. The clamp C is forced down by coming against the catch plate, expanding the upper jaws and

pressing in the lower limbs. On the inside of the clamp C, and on the sides which move down the outer edges of the lower limbs, feathers of brass, E E, are securely fixed, which facilitate the movement of the clamp downwards, and are so shaped that when the clamp C is in the position shown on Fig. 4, it locks the hook and keeps the jaws properly expanded. To prevent too much expansion of the suspending jaws, a stud D is fixed to the inner side of one of the lower limbs.

It will also be observed that in the original hook the clamp was not prevented from coming down on to the lower shackles, but in the improved hook this is entirely prevented.

The outer shape of the clamp is much better in the improved hook, and the projections K K in the original clamp are done away with.

RAMSEY AND FISHER'S HOOK,

The invention of Mr. Ramsey, of Castle Eden Colliery, in the county of Durham, is also a detaching and suspending hook. Patented in 1876, it has not been long before the public; but as now manufactured, it merits, from its peculiar construction, careful notice.

Two independent jaws, A A, Plate XLII., are contained in a box of great strength; they are separately hung on the bolts BB, and separately actuated; and in ordinary working are kept firmly in position by means of the two keys C C, shown projecting slightly at the sides of the box. The keys rest upon two copper rivets, D D; but they are so constructed as to exert no pressure upon the copper rivets until an overwind takes place. When the hook passes up into the strong cast-iron ring E fixed in the head gear, the two keys come simultaneously into contact with the conical lower end of the ring, are pressed downwards, and by cutting the copper rivets, and pressing the lower ends of the jaws together, they open the top ends so as to catch upon the ring, and release the shackle and rope.

As the rope disengages it draws up between the jaws a wedge F, rivetted by a small copper rivet to the links G, on the top shackle. The act of cutting this rivet is sufficient to firmly fix the wedge between the two jaws, securely locking them on to the ring and making it absolutely certain that the hook catches the ring properly, and perfectly impossible to shake it off again by any amount of jerking and shaking.

The tops of the jaws are kept extra large, and a hole bored in each, as shown. After an overwind it is only the work of a few minutes to couple a shackle on to each jaw, knock down the wedge, and, by tightening the rope with the engine, close the jaws and lower the cage safely on to the

keeps. By placing a little tallow or grease round the edge of the box the working parts are effectually protected from all damp and kept in perfect order, ready for action.

Each jaw being separately actuated, and it being necessary that both keys should be struck and both rivets cut before disengagement takes place, it may safely be said to be impossible to disengage the load in ordinary working. The fall back is in no case more than one inch, and partial overwind cannot take place to disengage the hook, as the jaws must be in position to grip the ring before the rivets are cut.

BOOTH AND SUGDEN'S HOOK.

This hook was patented so late as November, 1879, by Messrs. Booth and Sugden, of Hollinwood, near Manchester, and the writer has been supplied by Mr. Thomas Sugden with the following particulars. A drawing of the hook is given in Plate XLIII., Figs. 1, 2, and 3:—

A box is secured by the usual D links to the socketing or capping at the bottom of the winding rope, and to the cage chain in this box the hook or bar to be released is secured, the box being shaped out to receive the same. In the hook there is a hole shaped out in which a stud A is inserted; this stud carries the load, and has a bearing on each side of the box, which is prepared to receive it. Below the hole a wing or wedge-shaped projection is fixed upon, or rather shaped upon, each side of the hook, the wings being thickest at the lower end, and tapering upwards.

Immediately opposite the bearing stud, and in the same line with it, is fixed another stud B, which is the forcing stud.

Both studs are kept in position by copper pins screwed into the box, and both are chamfered off on the lower edge so as to form an inverted V when together.

The end of the forcing stud B projects outside the box while the whole of the bearing stud is concealed within the box.

Near the pulley is fixed a beam or beams, to which an iron casting, through which the rope passes, is secured. The casting is constructed to receive the box, and to detach the rope when the box is drawn through the aperture which is constructed on one side with a tapered slot, having its deepest part at the lowest edge, and on the other side with a corresponding projection. This is so arranged that the box in passing through the aperture causes the projecting part of the forcing stud B to come into contact with the bottom of the slot, the forcing stud B being then pushed inwards into contact with the bearing stud A, which is thus forced outwards, when the box has been drawn through the aperture sufficiently

far, that the forcing stud is clear of the top, both the forcing stud and the bearing stud at their inside ends form together an inverted V exactly opposite to the hook. The hook being slightly narrower than the bottom of the V, readily enters. The ends of the studs are now just clear above the aperture; the box is held at this point by projections which prevent it from going through the aperture, so that the hook is drawn through the V, forcing the studs outwards to a distance sufficient to project so far over the sides of the aperture as to hold the cage securely in position.

After disconnection has taken place, the rope can readily be connected by placing the hook in the box and forcing the studs back, so that it will again descend through the aperture. This is done by means of screws placed at the top of the aperture for that purpose. The lowering of the box through the aperture forces back the studs to their original positions, and winding can then proceed as usual.

If the rope comes to a position of rest when the box is in the aperture, and afterwards be made to descend, in descending the projection in the aperture forces back the studs to their working position, so that the hook quits the aperture in exactly the same condition as it enters, thus obviating accidents from what is known as partial overwinding.

This hook is only applicable to shafts in which guides are used, and cannot be applied to a sinking pit.

FORSTER AND ROBINSON'S HOOKS.

The invention of Messrs. Forster and Robinson, of the Water Works, Newcastle-upon-Tyne.

The writer has carefully examined a model of one of their hooks, and a drawing of another, and hopes to be able to furnish drawings and details at a future time.

The writer might have added, had he thought it would serve any good purpose, descriptions and drawings of other hooks which have been brought under his notice;* but as they did not possess any feature of special interest, and were in his opinion defective in design, he has not done so, and he proposes now to offer a few remarks on the hooks noticed.

Bryham and Knowles's hooks belong to the class of simple detaching hooks, the principal difference being that in Bryham's the hook goes with the rope, and in Knowles's it is left on the cage top. They are both good

* Other hooks have been illustrated in Vol. XIX., Appendix I., of the Institute Transactions.

hooks, and with the aid of safety-catches in the receiving rods they have done good service, and point to what a large number of people consider as a necessity, even along with detaching and suspending hooks, namely, receiving keeps, or suspenders, in the head gear, and this is especially necessary in the case of a very rapid overwind. When in use along with a detaching and suspending hook, they are designed to meet the possibility of either a collapse of the hook or the breaking of the cage chains by the sudden shock to the hook and chains, caused by the momentum which the cage has acquired by its upward velocity, carrying the cage upwards, after the hook has done its duty and released the rope; and a fear that in falling back the chains or hook, or some part of them, might give way. To take the shock off the cage, chains, and hook, Mr. Stephen Humble has invented what he calls a "Patent Safety-Cage Suspender," which meets all the requirements of the case.

King's and Ormerod's hooks have been before the public for a considerable time, and have answered the purpose for which they were intended very well; but the writer thinks that King and Humble's hook is superior to either.

The "Grange hook," which also belongs to the same class as King's and Ormerod's, is of recent construction, and has not yet been severely tested in actual practice, but considering the careful way in which it has been proportioned and constructed, and the great strength of plate over the top shackle bolt, it cannot fail to take a good position.

Walker's original hook has now been before the public for some years; but the writer thinks his improved hook a considerable advance upon it, not only from the improved locking, the absence of wings in the clamp, and the preventing of the clamp falling upon the lower shackles, but as being generally a better hook in every way.

Ramsey and Fisher's is especially good in design, and although apparently complicated, is exceedingly simple and sure in its action.

Objection has been taken to the use of safety-hooks on the ground that they may make the engineman careless, but this is not a valid reason. It ought, however, to be a rule that whether safety-hooks are applied or not, the engineman who makes an overwind, except when testing the hooks under direction, should be fined or dismissed.

Another objection to their use is, that the distance between the flat sheets and pullies is lessened by the fixing of baulks or girders to carry the detaching apparatus, and that it is probable, had there not been such apparatus, the engineman who started his engine the wrong way would have had a greater distance in which to correct his mistake. The number

of lives lost from this cause, as has been already shown, is exceedingly small, and these would have been saved had safety-hooks been applied.

There is also another objection made on the ground that something might fall down the shaft when the load was running and cause detachment. This, although possible, is met by the fact that hooks are now made which have such very slight projections that it is very remotely probable they would be struck; and further, even if one side was struck, it would not cause entire detachment.

Safety-hooks are only a portion of the colliery machinery, which ought at the same time as the ropes and chains to be carefully examined, and if this is done, there is no more risk in using a safety-hook than in using an ordinary shackle, and by their use many lives and much valuable property will be saved.

There is one part of the inquiry which the writer has left out for want of reliable information, and that is the amount of dead pull necessary to detach any of the safety-hooks described, and as he thinks it a matter of importance he trusts that the subject will be taken up by some other member or a small committee appointed by the Institute.

The points to be ascertained are—

1. The dead pull necessary to detach the hook when new.
2. The dead pull necessary to detach the hook after it has been left in a condition to represent working in a wet shaft for a definite period.
3. The dead pull necessary to detach the hook after it has been left in a condition to represent working in a hot and humid upcast shaft for a definite period.

In conclusion the writer begs to express his thanks to the various inventors of the hooks described for the information supplied, and to the Secretary of the Institute for extracts from the Mines Inspectors' Reports.

The President said, he was sure they were all very much obliged to Mr. Logan for the interesting address he had given to them upon the important subject of Safety-hooks. He would be very glad to hear any remarks which any member might have to make. Perhaps a general discussion would be better postponed until the paper was in the hands of the members.

Mr. D. P. Morison thought the subject which had been brought before them was one of great importance, and had received full justice at the hands

of Mr. Logan. That gentleman had evidently taken great pains with the paper, and had gone into nearly every detail they required on the subject. There were one or two points in the paper which he would like to comment upon. Mr. Logan mentioned the fact, that out of the whole body of Government Inspectors, there were only two who at all objected to the use of safety-hooks. One of these (Mr. Hedley) he was sorry to say was not alive, but he believed that Mr. Hedley's opinion was given before the introduction of safety-hooks as now improved, so that perhaps his opinion might now have been modified. He thought he was at liberty to say that Mr. Ralph Moore now recommended safety-hooks in collieries under his control, and it might be said that the whole of the Inspectors in their reports had shown that some action should be taken by the collieries, and that the Government also appeared to desire their use. He observed that out of the total loss of life in the shaft 99 per cent. might have been saved by safety-hooks; and that of itself was a point which should be brought before the public. He would further remark, that although no particulars are taken down as to the loss of property which occurs through the absence of safety-hooks, yet he believed that a great deal of property had been saved by their use.

The PRESIDENT thought there were safety-hooks of a somewhat earlier date than those Mr. Logan had described. He himself had a small model which had belonged to the late Mr. Matthias Dunn, which was very old.

Mr. STEPHEN HUMBLE said, King and Humble's hook had been tested a great many times, yet he would be most pleased to supply one or two hooks to any colliery in the immediate district for the purpose of trying them before a committee of the Institute, in the manner which Mr. Logan suggested, and he hoped that all patentees or makers of hooks would do the same.

Mr. D. P. MORISON said, that Mr. Fisher, who was present, but who was not a member of the Institute, would make exactly the same offer either to a committee or any private colliery which would like to make the test.

Mr. LAWRENCE said, that he had applied an hydraulic weighing machine to the hook made at the Grange Ironworks and found that in drawing the hook through the ring the strain required to shear the copper rivet, which was half-an-inch in diameter, was 75 cwts. He was not satisfied with the first experiment, but on repeating the trial the result was so nearly the same that he concluded it represented pretty accurately the force required to disengage the hook. This, he thought, would effectually remove the objection of those who thought that accidents might arise by any accidental strain on the shearing part of the hook. In order to arrive

at data whereby hooks of this make could be properly proportioned, he made a seven-ton hook of three forged scrap iron plates and sent it to the registered test, and the two outside plates gave way across the bolt-hole forming the axis, at a strain of 56 tons; he then had one made of forged steel from the Attwood Steel Works, Wolsingham, the same size in every way as the iron ones. When this was tested, the wrought iron shackles, which were of the same size as with the iron plates, gave way at 56 tons. In reply to a question from Mr. Humble, Mr. Lawrence said, that he would be very glad to give all the dimensions of the hooks and shackles to Mr. Logan, so that he could embody them in his paper.

Mr. Stephen Humble said, that he also carried out a series of tests at the Government Proving House at Tipton, for the purpose of ascertaining the best material for making the hooks. He had a six-ton hook sent there; the shackles were $1\frac{3}{4}$ inches in diameter, and all the pins of the same size. The plates were one inch thick and made of Bowling iron; another made of Landor Siemen steel; and a third of best Staffordshire iron. The best Staffordshire plates broke short off through the hook at 21 tons, which very much surprised him, and he instantly discarded the use of Staffordshire plates. The Landor Siemen steel broke quite suddenly at 45 tons, but the plate was drawn out about one-eighth of an inch. But with the Bowling iron, that portion of the hook in tension near the pin tore away, at a strain of 54 tons, sufficiently to allow the shackles to slip away; the outside portion of the hook in compression did not give way in the slightest degree, consequently the hook was not separated entirely from the plate, and in consequence of this experiment the hooks were now made entirely of Bowling iron.

The President—Then Bowling iron is 20 per cent. stronger than Siemen's steel?

Mr. Stephen Humble—So it would appear.

Mr. Lawrence said, that in future he intended to have all the hooks made at the Grange Iron Works, tested to double the strain they were intended to work under; and the tests he had described had been made to enable him to proportion all parts of the tackle so as not to give way under eight times the working strain.

Mr. Stephen Humble said, that this should always be done, and perhaps even a larger margin provided to allow for the extra strain upon the hook at the moment of detachment, and he read a certificate from the Superintendent of Lloyds' Proving House, Tipton, showing that the inside plates of a six-ton hook which he had sent there to be broken to destruction fractured at $54\frac{1}{2}$ tons, and the pins and shackles bent not quite $\frac{1}{8}$ of an

inch, thus proving that the breaking strain of his hooks were made considerably stronger than nine times the working load. At the Blackwell Colliery an experiment had been made in order to see what the weight of load would be upon the hook at the moment of detachment. A hydrostatic weighing machine was suspended from the bottom shackle of the detaching hook to the bull ring of the cage chains. The cage and load weighed five tons, and a self-registering indicator was placed on the weighing machine to show what the strain would be in case of overwinding. The engineer was then told to start and overwind at full speed; detachment took place, and the strain upon the hook indicated by the weighing machine was 10 tons 10 cwts., or more than double the weight that was in the load. Objections were sometimes made that hooks were likely to get out of order from rust. He thought this was a very poor objection, for as every part of the colliery plant should be thoroughly examined and cleaned from time to time and kept in perfect repair, why should the hook not be examined and repaired as well? and he thought that this could be done effectively if they were taken to pieces and cleaned every two months.

Mr. May said, there was one question which he would like to ask—whether they consider hooks safe in cases which frequently occur at collieries where different decks had to be loaded, and where the hook had to go down and lie upon the cage and then be drawn away again, and whether in these cases there was not a tendency for the hook to come loose in the same way as it might do by anything falling down the shaft and catching the projecting flange or trigger?

Mr. Lawrence, in reply, said he believed that nearly every time the cage arrived at the bottom of the shaft the hook struck the roof of the cage, but he had never heard of any of them having become injured thereby.

Mr. D. P. Morison said, that Ramsey and Fisher's hook by its box shaped exterior and small and independent projecting parts, would entirely meet the case put by Mr. May. No shaking or vibration upon this hook, and no blow of any description whatever, could possibly disengage it. All hooks which depend upon projecting plates were open to the objection that a blow upon any one of them had a tendency to shear the copper pin and disengage. Even if the pin was not sheared through, they had found in the case of the small models which had been exhibited and shown for some time that it had a tendency to bend, or to become marked in such a way as to become unsafe after a certain degree of work. He thought, therefore, that the question which had been put

by Mr. May was a very pertinent one indeed; and he trusted that the whole matter would be investigated either by a committee, or at some colliery where the proprietor might be induced to take the trouble of testing the different hooks. He would also suggest that any violent test which the different hooks might have borne should be explained before that committee. He was informed, and believed it perfectly true, that the hook of Messrs. Ramsey and Fisher had been tested very severely, and it had been found that the rope, shackles, and everything had given way except the hook itself. He suggested that the inventors be asked to send in to Mr. Logan the results as a continuation of his paper. He would further advise that the points which each different manufacturer claimed should be indicated. Mr. Lawrence, for the Grange Company, pointed out certain advantages in his; Mr. Ormerod claimed others, and so did Messrs. Ramsey and Fisher; and he had no doubt their friend Mr. Humble claimed a great many points also; and he thought an addition embodying the results of these tests might be made to Mr. Logan's paper.

Mr. Logan said, perhaps they would permit him to make one or two remarks after hearing the discussion which had been going on. He was very careful in getting up his paper not to mention the materials of which any one of the hooks were composed, simply because when they made up their minds to buy any particular hook, it was the duty of the mining engineer to see that the hook was constructed of the very best material which could be got, and this the mining engineer was perfectly capable of doing. Mr. Humble thought the hooks ought to be examined every two months at the collieries, and that where this was done there was really not much danger. In answer to this, he would refer to a report on a plate hook at a colliery in South Durham, which is changed every month, when it is generally found that it is necessary to renew the large bolt in the centre and the copper bolt, to rime and square out the holes, and to chip the plates level.

The President asked if in the case of upcast shafts, where there was moisture, there was not risk of some galvanic action taking place between the copper pin and the plates?

Mr. Logan said, that if the tests which he suggested, and other tests which might suggest themselves to the proposed committee were carried out, this point along with others would be settled.

Mr. Stephen Humble said, of course there were exceptions to every rule; and in such shafts it was only necessary that the hook should be examined more frequently; he also alluded to the unfairness of some

BRYHAM'S HOOK, *to illustrate Mr. Wm. Logan's paper on "Safety Hooks."*

FIG. 1.

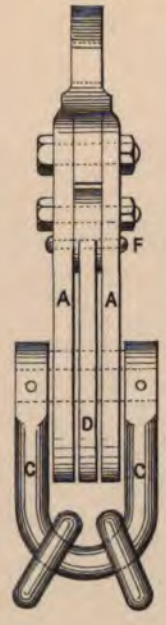
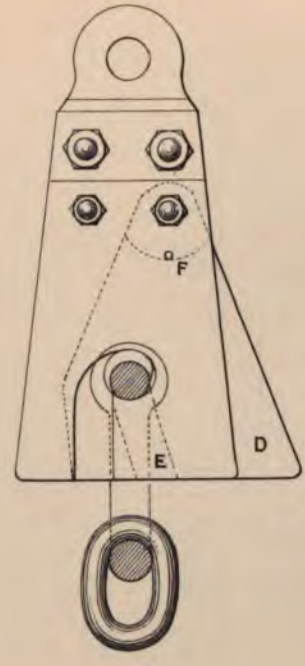


FIG. 2.



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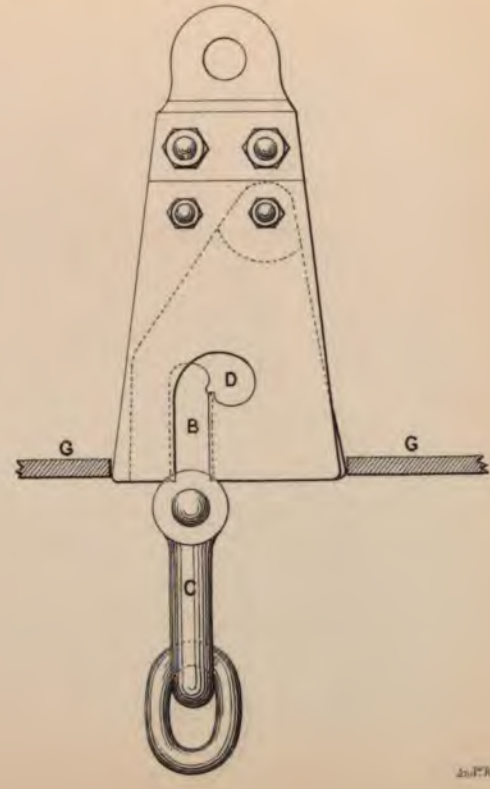

Scale Two Inches = 1 Foot.

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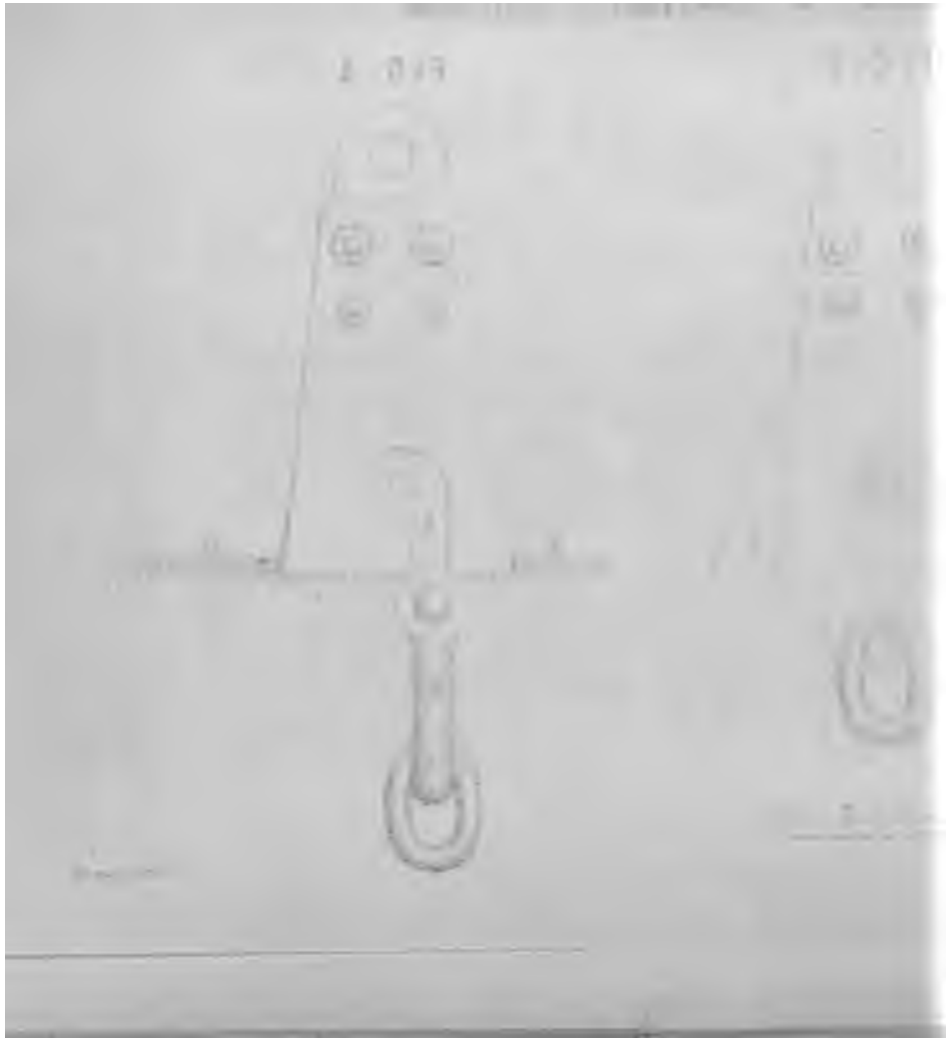
Jos. P. Reid, Newcastle.



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KNOWLES'S HOOK *to illustrate Mr. Wm. Logan's paper on "Safety Hooks."*

Scale 1½ Inches = 1 Foot.

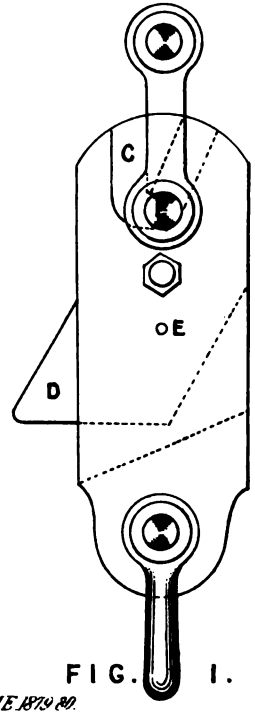
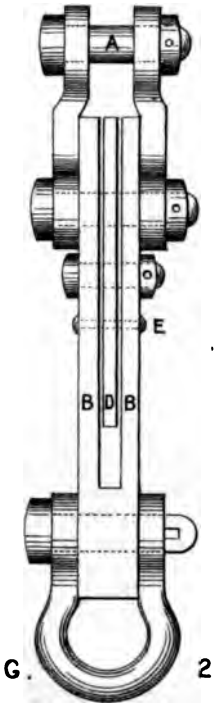


FIG. 1.



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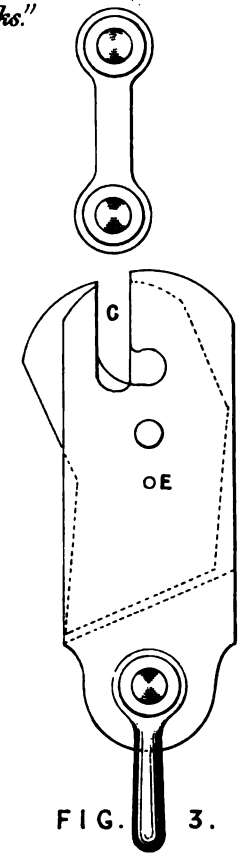

FIG. 3.

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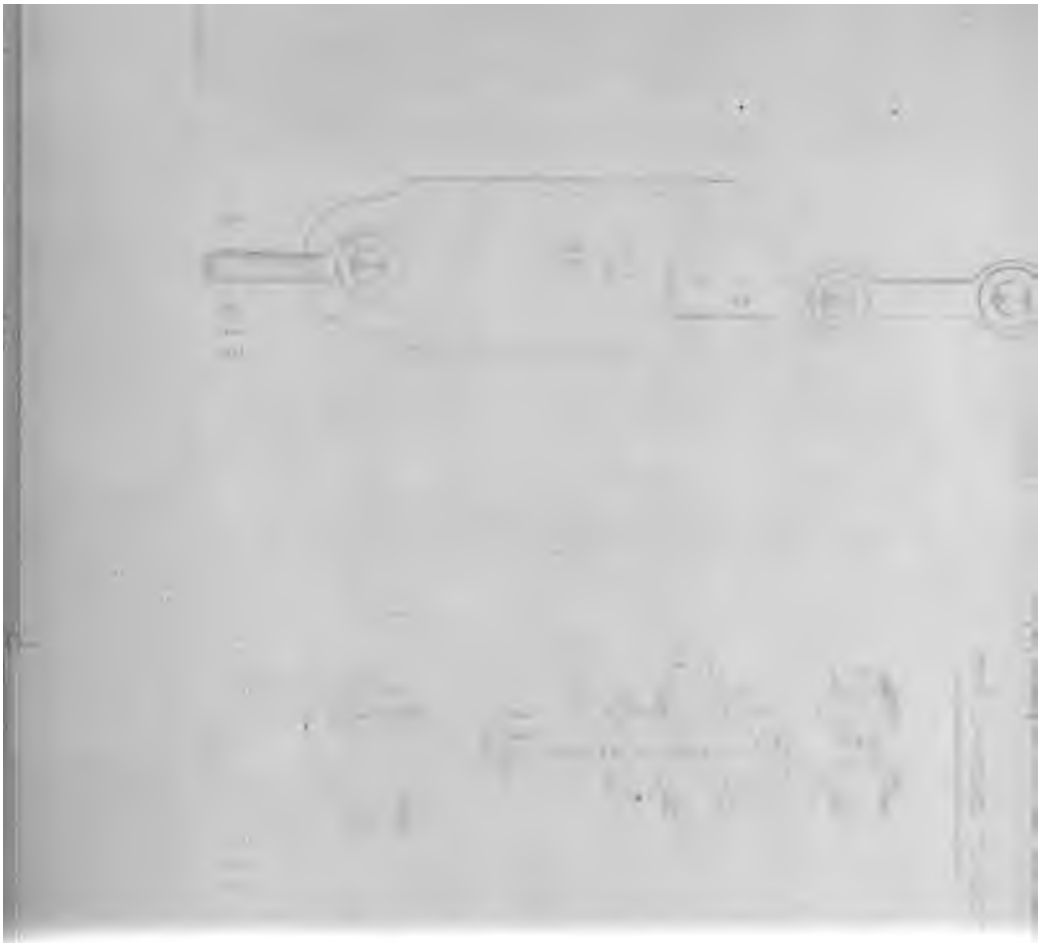
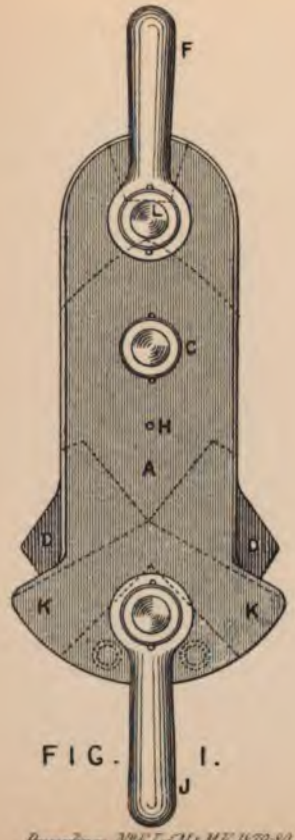
And. Reid, Newcastle



KING'S HOOK, *to illustrate Mr. Wm. Logan's paper on "Safety Hooks."*



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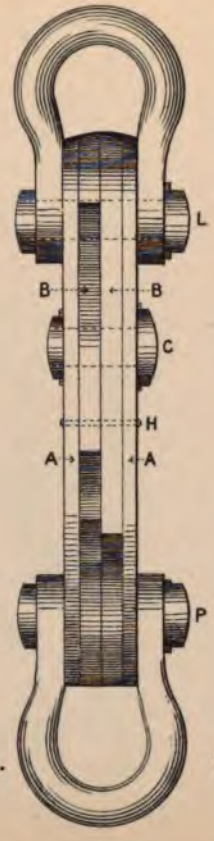

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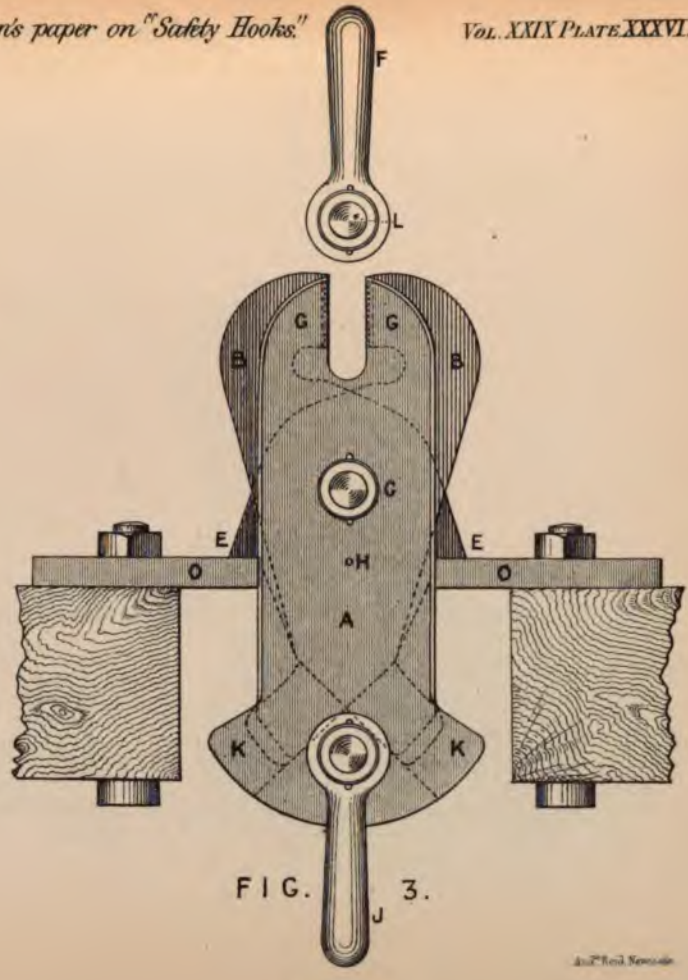

FIG. 3.

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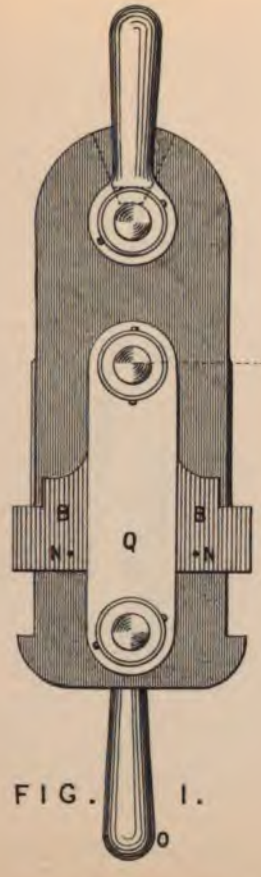
KING & HUMBLE'S HOOK, *to illustrate Mr. Wm. Logan's paper on "Safety Hooks."*



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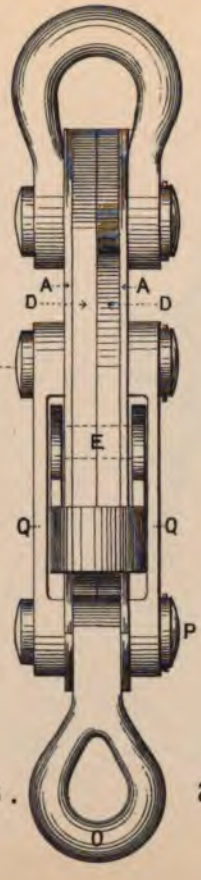

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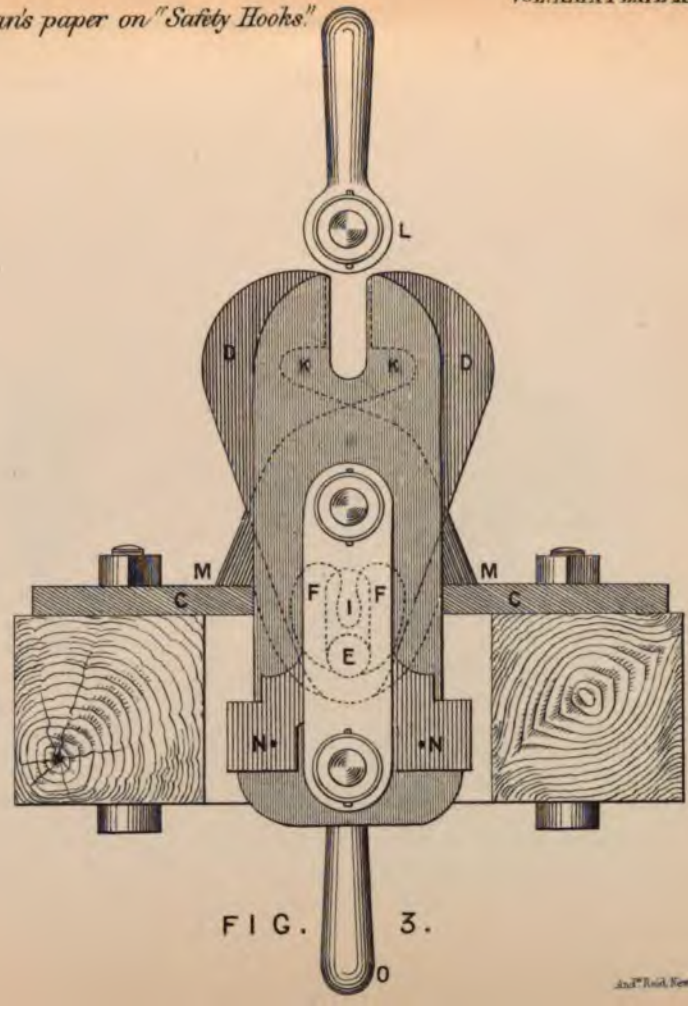
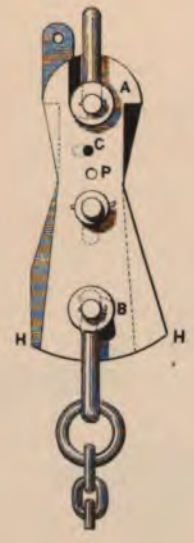


FIG. 3.

Proceedings N.E.I. of M. & M.E. 1879-80.

ORMEROD'S HOOK, *to illustrate Mr. Wm. Logan's paper on 'Safety Hooks'*



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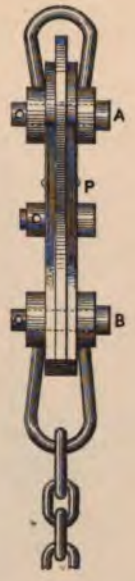
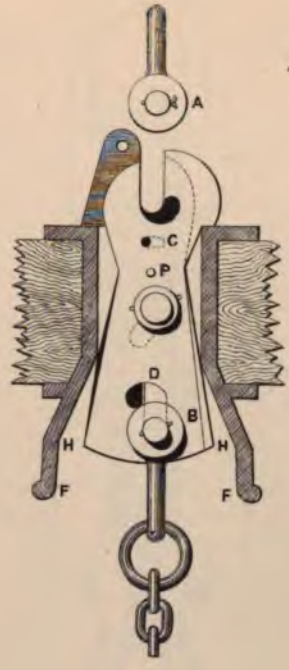


FIG. 2.



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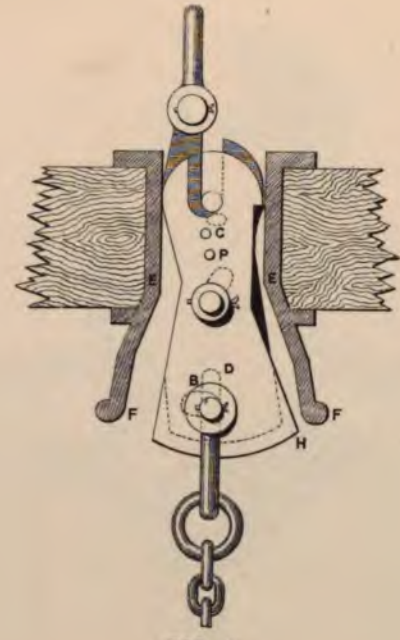

FIG. 4.

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Andrew Reid Newcastle

THE GRANGE HOOK *to illustrate Mr. Wm. Logan's paper on "Safety Hooks."*

Scale - 1½ Inches to 1 Foot

WORKING LOAD 7 TONS

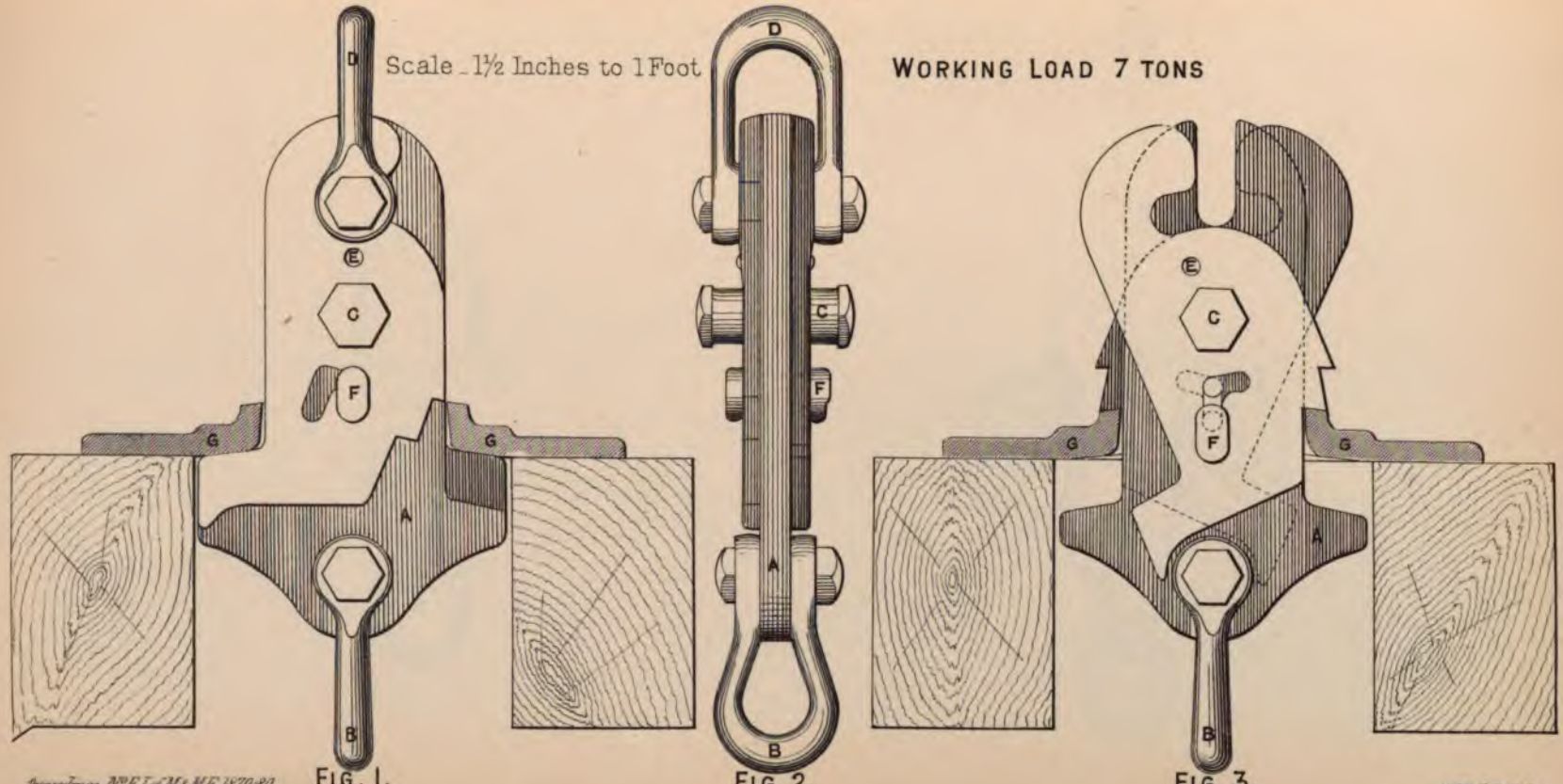

FIG. 1. FIG. 2. FIG. 3.

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Andr. Reid, Newcastle.

WALKER'S HOOK, *to illustrate Mr. Wm. Logan's paper on "Safety Hooks."*

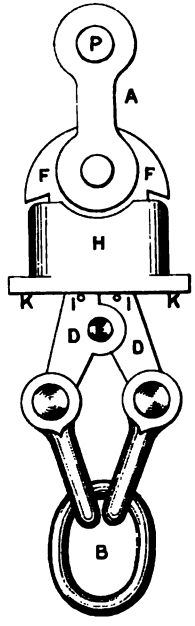


FIG. 1.

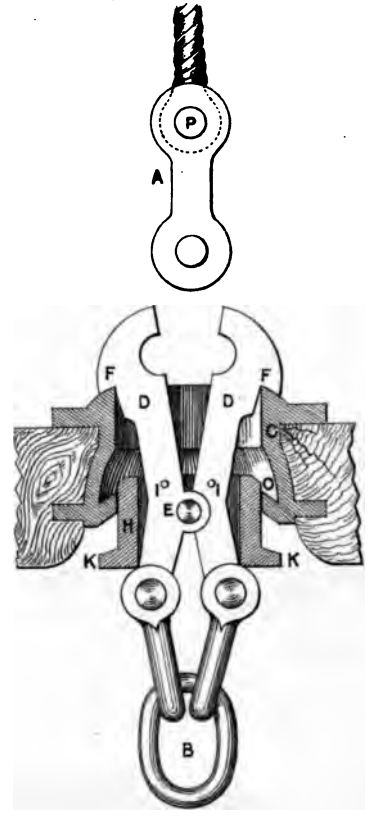


FIG. 2.

Proceedings N.E.I. of M.&M.E. 1879-80.

Arch. Reid Newcastle.

WALKER'S IMPROVED HOOK, *to illustrate Mr. Wm. Logan's paper on "Safety Hooks."*

Scale Two Inches — 1 Foot.

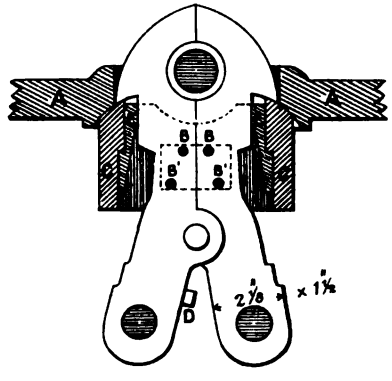


FIG. 1.

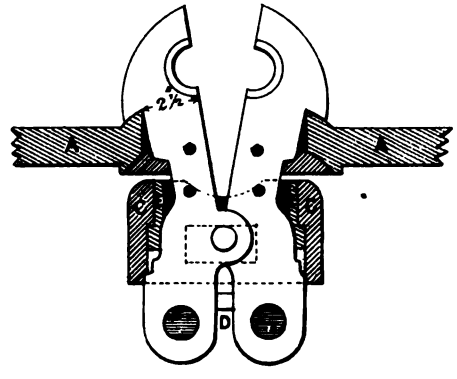
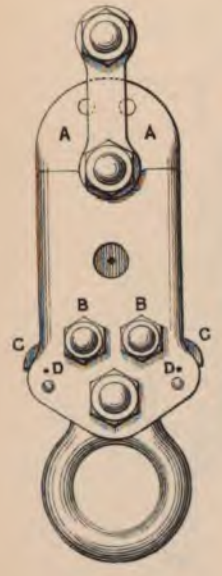


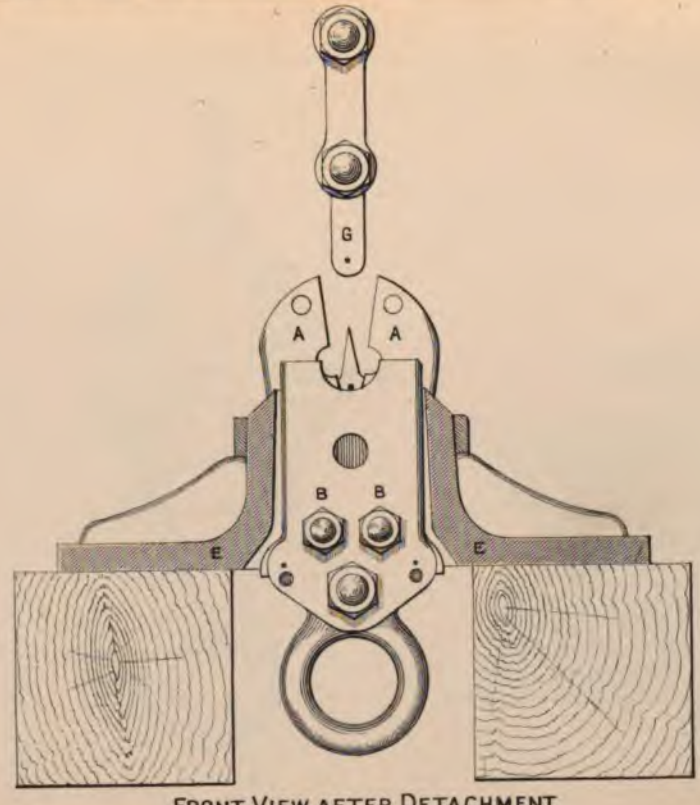
FIG. 2.

J. T. Reid, Newcastle

RAMSEY & FISHER'S HOOK *to illustrate Mr. Wm. Logan's paper on "Safety Hooks"*

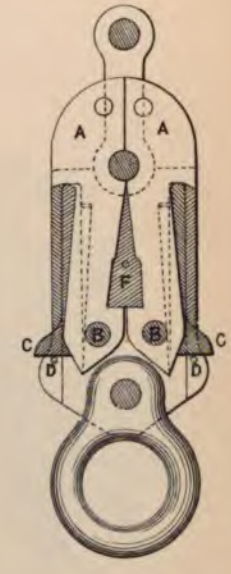


FRONT VIEW CLOSED



FRONT VIEW AFTER DETACHMENT.

SIDE VIEW



SECTION

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Dell & Red, Newcastle.

Booth & Sugden's Hook, *to illustrate Mr. Wm. Logan's paper on "Safety Hooks."*

Scale Two Inches — 1 Foot.

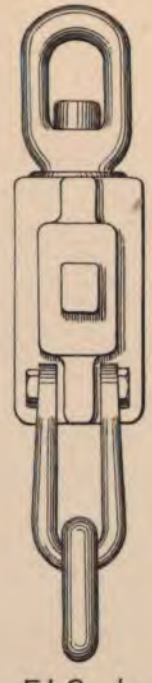


FIG. 1.

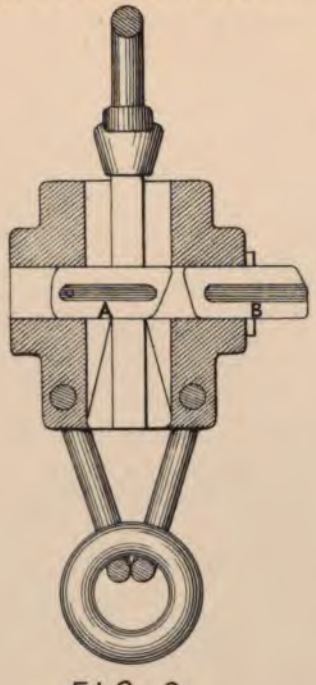


FIG. 2.

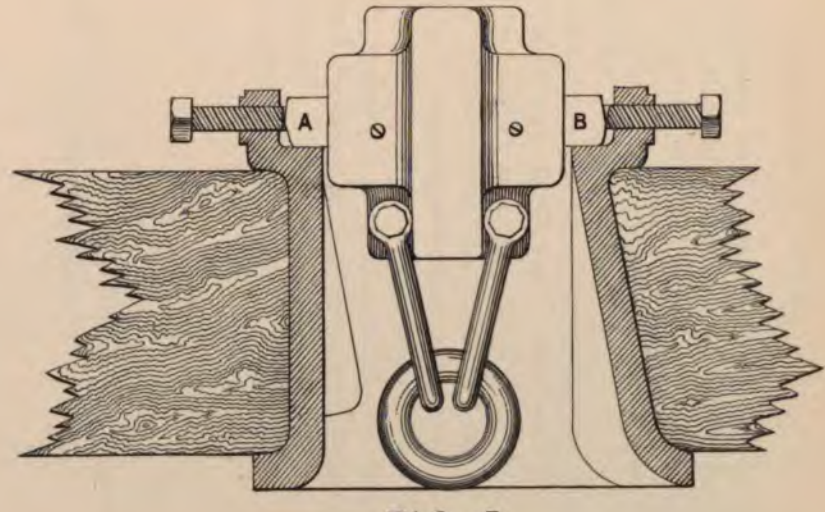


FIG. 3.

Ann. Reid, Newcastle.

colliery engineers using hooks for a larger strain than that for which they were constructed—in some cases making it carry double the weight—in such case, it was not the fault of the detaching hook if it gave way.

Mr. WILLIS said a three-ton hook, with a six-ton load upon it, would soon wear all the bolts loose.

Mr. WEEKS said he had the pleasure of rising to propose a vote of thanks to Mr. Logan for his very valuable paper. He thought it would be very desirable if the Institute took up the subject and appointed a committee, and tried to get some of these disputed points settled.

Mr. MAY said, he had very great pleasure in seconding the proposition. He agreed as to the advisability of a committee of the Institute being appointed, because the subject was a very wide one, and there were now so many of these hooks before the public that it was really a difficult matter to settle which was the best.

The vote was unanimously carried.

The following paper, by Mr. Thomas Heppell, on "Cranston's Pneumatic Rock Drill" was considered as read:—

CRANSTON'S PNEUMATIC ROCK DRILL.

By THOMAS HEPPELL.

THE process of drilling holes by hand must necessarily be slow, and when these holes have to be drilled in unfavourable situations the work executed is both expensive and tedious. Simple as the operation seems, it nevertheless, as in the case of file-cutting, has been found extremely difficult to get a machine to do it properly, although the subject has occupied the attention of many engineers who have had extensive tunnelling or sinking operations to conduct.

The most successful mechanical drills have been those which have approached nearest to the hand process, which may be thus described:—

1. A rod or chisel, with a levelled cutting edge, is applied to the rock.
2. A blow with a heavy hammer is given by the workman.
3. The chisel is lifted and partially turned, and the blow repeated, the chisel being lifted and turned between each blow.
4. When from repeated blows the chisel has entered so far into the rock as not to leave a sufficient portion outside for the workman to grasp, the chisel is withdrawn and a longer one substituted.

The hammer and the chisel thus used are of the most extreme simplicity, and the difficulty in substituting machinery for the hand process has been found greatly to rest in the complication of the parts required to produce the simple results detailed above, and the amount of inconvenience arising from this complication is in many cases so great, that in the Mont Cenis Tunnel it required five of the Somellier machines to keep one at work, four being always in the repairing shop.

Much of the complication of these machines is due to the means provided for causing the drill to make a partial rotation between each blow, and a characteristic feature in the machine now to be described is, that this operation is performed exclusively by hand.

After many years of extensive use, the machine, simple as at first designed, has been relieved of all unnecessary parts, and, in its latest and most improved form, may thus be described :—

Plate XLIV., Fig. 1, shows a longitudinal section of the machine, and Fig. 2 shows a section through A B, Fig. 1. C is a gun-metal cylinder provided with a solid bottom *d* and stuffing box *e*, the other end is closed with a wrought iron ring *f*, provided also with a stuffing box. The casting of the cylinders is prolonged to *g*, and provided with a cover *h*, which is bolted to it. The cylinder is provided with flanges *i* which slide in a groove provided for the purpose in the cast iron sleeve or support *k*, which, by means of the cone *l*, is secured to the box *m*, Plate XLV., Figs. 1 and 2. The piston *n* and rod *o* are in one solid piece, the top part of the rod *o* is swelled out to form a guide in the part *g* of the cylinder casting, and the other end is bored out to receive the drill; a slot *q* is then cut down the full length of the hole, and a ring *r* provided with two screws *s* is put over the rod. The drill is then inserted and the screws tightened up. The mode of fastening the drill allows the end of the cylinder to be made solid, and considerably adds to the strength and durability of the machine: *t* is a tappet, by means of which the valve *u* and the rod *v* are worked through the projection *p*, striking the tappet at each reversal of the stroke of the piston; and *w* is a small guide pressed up to the valve spindle *v*, so as to keep the valve from shifting in its place after the tappet *t* has ceased to be in contact with the piston rod; *x* is a small prolongation of *t* in the shape of a handle for starting the machine by hand; *y* is an India-rubber washer between two plates *z z*, the top one of which is screwed to the cylinder covers *n*, by the screw *a'* in the space *b'* between the plate *z*, and the cover *n* is the head *c'*, of a steel tube *d'*, which works inside the piston rod *o*, and is provided with a feather *e'*, by means of which the piston rod may be made to rotate if a rotating motion should be applied to the tube *d'*. Attached to the sleeve *k* is a bridle *k'*, which carries one end of the feed screw *q'*, which is provided with a long slot *m'* working in a feather in the clutch *s'*, and is geared into and released from the tube *d'* by means of the lever *n'*, which is kept in its place by means of the lever *o'*. The feed screw *q'* screws into a nut screwed to the cover *h*, and when turned round by the handle *q'* it causes the cylinder *c*, together with the piston and rod *n* and *o*, to slide forward into the groove *i* of the sleeve *k*, and by that means causes the drill to enter deeper and deeper into the rock. As has been before observed, the modern machines have no self-acting arrangements for causing the drill to rotate, and the rotation is done by hand in the following way. When the clutch *s* is out of gear with the head *c'* as shown, the drill can be advanced without having any rotatory motion communicated to it; but when the clutch is put in

gear by lifting up the lever *o'*, then the rotatory motion of the screw is communicated to the piston and the drill, and any amount of either rotation or advance can be given by the attendant. When the drill has entered into the rock as far as the screw will allow, the machine is drawn back to its original position and a longer drill inserted.

Plate XLV., Figs. 1 and 2, shows the machine held up to its work. The cone *l* of the sleeve *k* is held by a clamp *m* secured round an iron upright *b* by the bolt *c*. This iron upright is grooved as at *d d*, and in these grooves, as in a rack, works a wheel *e*, worked by a lever *f*, and this raises or lowers the machine at the will of the attendant. The iron upright *d* is secured against the roof of the gallery by means of the screw *g* and the lever *h*. The total weight of the stand with No. 2 sized machine is 3½ cwts., and as it can be readily taken apart, the whole is easily moved from place to place.

These machines are now made entirely without the self-acting motions (excepting in special cases), for practical experience has shown that the drills can be rotated by hand much more readily and reliably than by the use of any automatic gearing. There are, no doubt, many very highly ingenious arrangements both for automatically rotating and feeding the drill tool, and they generally work with great precision so long as the adjustments hold together. But it is self-evident that any fine adjustment of parts required in these machines, to automatically feed or rotate the drill, must sooner or later be destroyed by the constant hammering and pounding of the piston-rod. The efficiency and economical working of the machine are in no way affected by dispensing with the automatic part of the mechanism, which in the hands of unskilled workmen are necessarily most likely to become deranged. Besides, in most cases the rotating gear causes a considerable increase in the length of the working cylinder, which increases the difficulty of working the machine in positions much out of the horizontal.

There has to be a man in charge of the machine, and he might as well be rotating the drill, which he can do much better than can be done by self-acting gear.

The sense of feeling, in the human hand, indicates directly to what degree the drill should be rotated, so that it can be manipulated at will to suit the varying and unequal nature of the rock being drilled.

In most of these arrangements the piston rod must travel its allowed stroke each time before the rotatory motion can be obtained, and the rotatory motion is always the same, whether drilling in hard or soft rock; whereas, in this machine the miner can rotate his drill less or more,

sometimes backwards and sometimes forwards, and by the sense of feeling can chip away the rock to the best advantage. He can also keep his drill from "jamming" in joints or other uneven bearings in the hole. The drill bar can likewise be sufficiently rotated without relying on any definite pitch or stroke of the piston rod.

It will be seen, on referring to the drawing of this machine now brought under notice, that there are no grooves in the piston rod.

This advantage enables the machine to be compact, and of short dimensions; the rotating gear, when added, is free and independent of the cylinder; and the piston rod is guided substantially at three different points above and below the piston by two solid glands, and also at the top or near end of the piston rod by its crosshead. The whole of the machine being covered by the casing, grit or sand cannot interfere with the working parts.

The valve for admitting the steam or air to the piston as shown in the drawings is an ordinary D slide valve. It can be adjusted when deep holes are required with great facility, to give more power on the bottom of the piston to counterbalance the increasing length of the drill rods, which necessarily get heavier as the hole deepens. In the Hematite Iron Mines of West Cumberland, holes are very frequently drilled vertically up into the roofs by the machine, and by its means large quantities of mineral are quickly and economically quarried down by a single blast hole. These roof holes are drilled quite easily. It is only required to unscrew the valve spindle in order to give more power on the other or top end of the piston. Water is not required, as the dust falls readily from the hole whilst it is being cut away by the drill.

At Pateley Bridge Lead Mines, in Yorkshire, an extensive plant has been put down to work a number of these drills by air. Two double-acting compressors are placed on each side of the steam cylinder, and the cylinders and compressors are all connected to the fly-wheel shaft, so that the steam is executing its greatest power when the air is at its highest stage of compression. The air is conducted to the shaft by 125 fathoms of 3-inch pipe. It is then continued other 68 fathoms down the shaft and 100 fathoms along the level. The whole plant, including the foundation for the air-compressors, was put down in a fortnight, ready for work. The drills are working in hard, compact, solid limestone, without joint or opening, which formerly required the very best miners in the neighbourhood to work with any advantage. The machinery now does 150 per cent. more work at 20 per cent. less cost.

To illustrate Mr. T. Heppel's paper on "Cranstons' Pneumatic Rock Drill."

FIG. 1

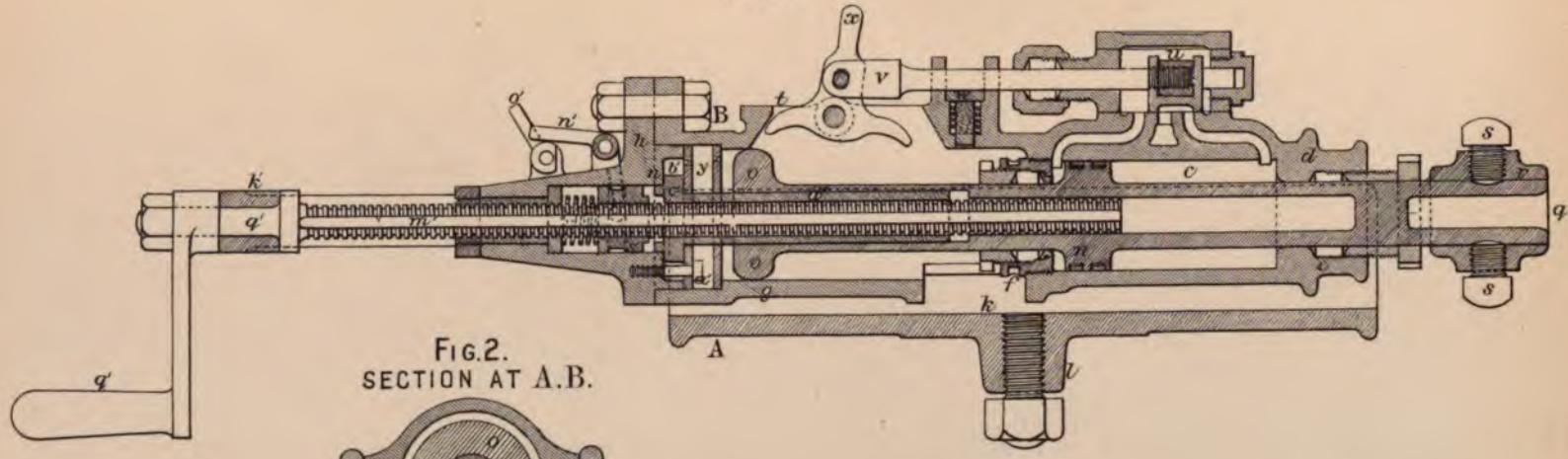


FIG. 2.
SECTION AT A.B.

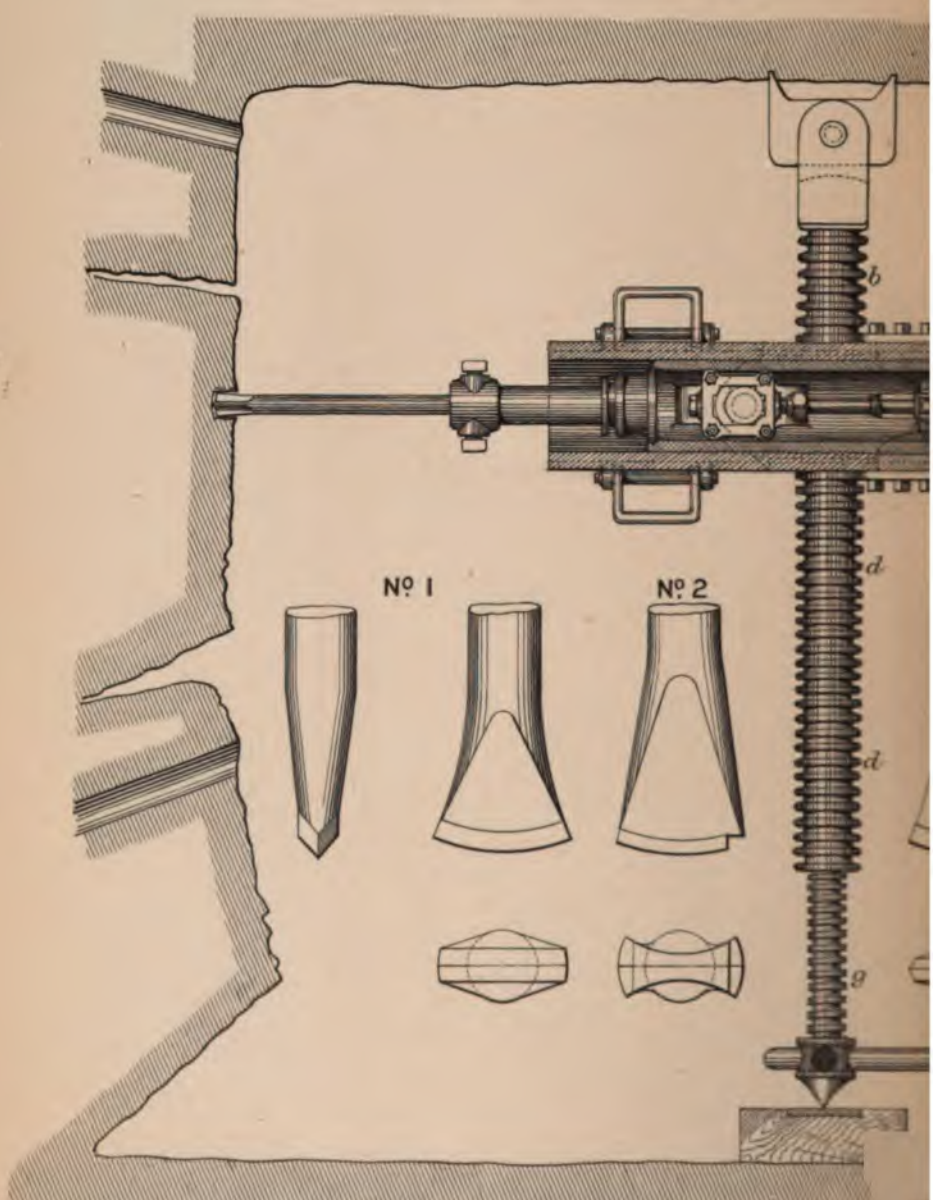
Scale _3 Inches to 1 Foot

Ant. Tod, Newcastle.

To illustrate Mr T. Heppel's

Nos 1 to 7 Shew the V

Fig. 1.

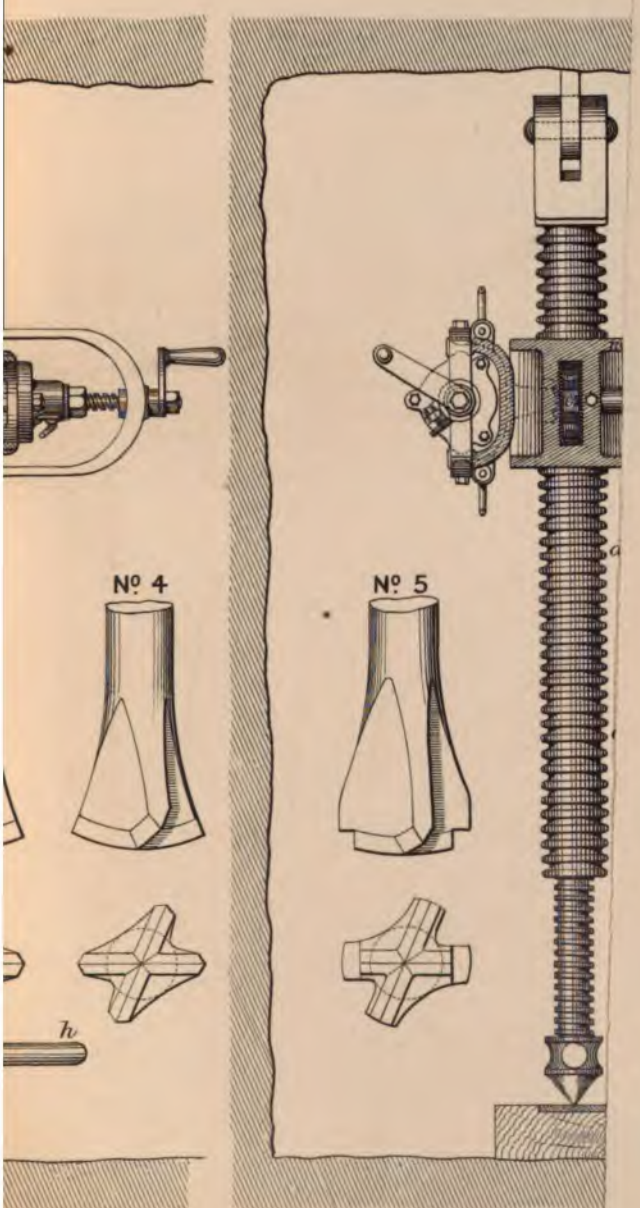


Proceedings No. E. I. of M. & M. E. 1879-80

on "Cranston's Pneumatic Rock Drill".

S FORMS OF DRILL MOST IN USE

FIG. 2



At West Moor Limestone Quarries, Durham, work which cost 1s. per foot by hand is now done for 2½d per foot. This includes the total cost of fuel, labour at boiler, engine, and drill, fitting drill bits, and repairs to the borer. During the last five years one machine has drilled 18,000 feet of 2¼ blast holes in one year, and at several times has drilled 7,000 feet without repair.

These remarks will sufficiently illustrate the nature and mode of working of the machine and its general economy. The mode of compressing the air, which has been found in practice the most beneficial, will perhaps form the subject of a future communication.

A vote of thanks having been awarded to Mr. Heppell, the meeting terminated.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, JUNE 19TH, 1880, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

G. C. GREENWELL, ESQ., PRESIDENT, IN THE CHAIR.

THE SECRETARY read the minutes of the last meeting, and reported the proceedings of the Council.

The balloting list for the election of officers at the annual meeting in August was submitted to the meeting.

The following gentlemen were nominated for election at the next meeting:—

ORDINARY MEMBER—

Mr. GEORGE BARKER, M.E., Tay Iron Works, Perth.

ASSOCIATE MEMBERS—

Mr. THOMAS AUDUS, Mineral Traffic Manager, North-Eastern Railway, Newcastle-upon-Tyne.

Mr. JAMES FAIRLEY, Colliery Manager, Craghead and Holmside Collieries, Chester-le-Street.

Mr. LINDSAY WOOD read a paper descriptive of numerous experiments which had been made under his direction at the Hetton, Boldon, and Harton Collieries, to ascertain the pressure of gas in the various seams of coal, but the author being desirous of making further experiments in the same direction and of embodying the results in the paper with the view of rendering it as complete as possible, its publication has been withheld for the present.

After Mr. Lindsay Wood's paper had been read, the PRESIDENT invited discussion on Mr. James I'Anson's paper "On Apparatus for the Prevention of Overwinding," and said that the apparatus was very similar

to that described by Mr. Heth Ogden, in a paper read before the South Wales Institute of Engineers on the 23rd of July, 1859. He (the President) had applied that apparatus to a winding engine at a colliery in Somersetshire. He had it constantly examined and frequently tested; but in testing it one day it failed.

Mr. J. A. G. Ross said, it seemed to him that the principle enunciated in the paper was the right one, inasmuch as it introduced no new element of danger as did the safety-hook, which, unless one could be invented that was absolutely perfect, was a continued source of danger during the whole of the winding. But there seemed to be one defect, viz., that the cage acts upon a throttle valve and then upon the brake apparatus. Now, this might do very well when the cage was working slowly; but supposing it came up at the rate of twenty miles an hour, or 30 feet a second, at which rate he supposed a cage did sometimes travel, it would take at least a second before the apparatus could be brought into operation, which second meant 30 feet. Supposing the engine stopped instantaneously after this, the cage would be carried up 17 feet more by its *vis viva*. He thought an improvement of the system would be to make it act by means of a governor, so as to regulate the speed and cut off the steam automatically when the cage was some distance from bank.

Mr. Hudson, present on behalf of Mr. I'Anson, said, if he understood the last speaker correctly he thought the apparatus was in the right direction, only that it would be inoperative at very high velocities. Now he (Mr. H.) had tried an experiment at the Lingdale Mines to test this. The engines were 36 inches diameter, working at a pressure of 30 lbs. to the square inch, the drum was 20 feet in diameter and the engines brought the cage from the bottom to the top in thirty seconds, which was something over 20 feet a second, or fourteen miles an hour. The break lever had a leverage of six to one, and was attached to a steam cylinder of 14 inches diameter. This put a pressure tending to compress the brake of about ten tons, applied to about one-third of the circumference of the drum. This apparatus when suddenly applied, by letting go the catch when going at full speed, stopped the engine in one-quarter of a revolution, which was equal to 15 feet travel of cage, and he thought that if the same power had been applied to a brake encircling the whole circumference of the drum, it would arrest it in one-eighth of a revolution, or 8 feet travel of cage. In a fortnight there would be an engine at work with the apparatus attached, and then he would be in a position to speak more positively about it.

Mr. G. B. FORSTER did not think there were many places which would allow of a space of 8 feet, or even 2 feet, to stop in.

Mr. HUDSON said, it was merely in answer to Mr. Ross that he had endeavoured to show from his experience the practicability of stopping the cage in a space of 8 feet, but with proper arrangements he thought that there would be no difficulty in stopping the drum instantaneously. There was also a great advantage in the system inasmuch as it came into operation without putting any shock upon the engine; whereas the safety-hooks, when they came into operation, put a strain upon the rope of 5 tons in excess of the load, according to experiment, and supposing the load to be 5 tons, that would be 10 tons on the periphery of the drum, which in most cases is three to one of the crank; and if so it would give a shock of 30 tons to the crank pin.

The PRESIDENT said, if there were no further remarks to be made on Mr. I'Anson's paper they would proceed to the discussion of Mr. Logan's paper "On Safety-Hooks." In opening the discussion on Mr. Logan's paper he said that the classification in page 202 did not appear to lead to any accurate conclusion, for it was not known what failures might have occurred had the apparatus been applied in those other cases of overwinding, or with regard to the items 7 and 8, recording six lives lost by safety-hooks, how many lives might have been presumably saved by the use of them. Even then it does not necessarily follow that all of those assumed to have been saved by their action would otherwise have been killed; and it remains to be proved that all of those others who were killed, according to the Table, would have been saved if safety-hooks had been in use. He had not heard of any case where a safety-hook of the self-detaching and self-suspending type had been brought into action in which the cage had dropped away by reason of the breakage of the cage chains, although he thought he remembered hearing of such an accident having occurred from the collapse of a hook; but in the view of either of these events happening, it seems to be prudent to have in all cases safety-catches, such as those employed with Messrs. Bryham's or Knowles's hooks. He did not quite agree with the writer of the paper as to the invalidity of the reason for objecting to safety-hooks on the ground that they make the enginemen careless: it would not be difficult to bring evidence to show that at collieries where, until the introduction of safety-hooks, overwinding or "pulleying" was comparatively unknown, these freaks had become of too frequent occurrence. He knew of a case in which an engineman,

winding water at night, drew the cage up to the safety-ring; the hook acted; he, without aid, managed to re-attach the cage: to get out the water in the usual time; and it was not until afterwards that any one knew anything about it. As to the strain which is necessary to shear the copper pin, he thought the statement that it requires 75 cwts. to shear a copper pin or rivet, half an inch in diameter, ought not to be allowed to lead to misapprehensions—it must be understood that this meant 75 cwts. of dead force; and as, when suspended, the cage and coals in such a case would be very much in excess of this weight, it only pointed to the necessity, in order to ensure abundant safety, of so locking down the ring plate and framing that it shall be able to resist an upward strain equal to the weight of the cage and coals. But in the process of shearing there will be suddenly added 75 cwts. to this weight, thereby greatly increasing the risk of breaking the rope above the hook; and if this did happen, it would be before the hook was brought into action, which showed the necessity of a safety-catch beneath in all cases.

Mr. G. B. Forster said, he quite agreed with the President's view that some sort of catch should be placed below these safety-hooks in case of anything giving way, for although he had never known an instance of the cage falling after the hook had been called into play, yet he had had a case in which a full cage coming to bank and stopped by the safety apparatus had so damaged the chains that they were obliged to be taken off. He had used safety-hooks for a long time without accident, and although he would not like to take the responsibility of recommending one more than another, he must say he had never known anyone of those which he used to fail, except one, through an accident which caused a tub to fall down the pit while the cage was standing at the bottom; this of course was a very exceptional case, and could hardly be expected to happen without causing damage; but he believed in the principle of having safety-hooks on every rope in use. Although he with others imagined there were more cases of pulleying than there used to be, yet he did not really believe that this would be found to be the case if a strict investigation was made. Of course more is heard about these cases now, because they have to be reported and put upon record; but whether there are more cases of pulleying or not, he thought that if in one case of pulleying lives were saved by safety-hooks, it amply repaid any inconvenience caused by having the cage overwound a few more times than usual.

Mr. D. P. Morison asked if the case which Mr. Forster mentioned about the full cage coming up and damaging the chains was the only case of overwinding which he had had?

Mr. G. B. FORSTER—No; it was the only case in which the chains were damaged.

Mr. MORISON asked if Mr. Forster had made any comparison of whether the full cage or the empty cage did the greatest damage in cases of over-winding? Because in his (Mr. M.'s) experience he found that the empty cage as a rule jumps about in a very much more dangerous way, and damages the ropes and chains and everything else more than the full one.

Mr. G. B. FORSTER said, that the cases which had come under his notice in which the empty cages had been taken up to the pulleys had only been where the engine had crept away or been started gently, and no damage was caused. In the case he had referred to, where there was damage, the engine was going nearly full speed with a load of four tons, in coals and tubs, in a cage weighing one-and-a-half tons.

Mr. MORISON said, that was a very important fact, and went to disprove the assertions that had been made that cages would continue their upward movement from the force of their momentum after the safety-hooks had come into action, for if this were so, and they rose to anything approaching the extent indicated by some of the members, the fall-back of such a weight as that spoken of by Mr. Forster would be sure, not merely to damage, but to break the chains and render it necessary to have more than one set of keps under the hooks. He believed that where the fall of the cage after disconnection had caused damage, it had been where such hooks were used as fell back after coming into action, which some of them did to the extent of from four to eight inches; and a weight of five-and-a-half tons falling even that short distance would be sure to damage the chains considerably.

Mr. S. HUMBLE said, that he had very frequently during the testing of King's hooks at high speed found the loaded cage ascend very considerably after becoming disengaged. In one case, at Morley West-end Collieries, near Leeds, it rose 7 feet 6 inches and fell back upon the hook, but the chains and hook were not affected in the slightest; and he did not think this falling of the cage interfered in any way with the efficiency of the system. In King's hook, under any circumstances, and in all cases, the hook was at rest upon the plate before the cage fell and at the instant the rope was detached.

Mr. H. LAWRENCE, alluding to a case in which the catch-plate had been broken when the hook came into operation, asked Mr. Humble how he could account for it if it was not caused by the jerk of the load falling back upon the hook?

Mr. HUMBLE said, the fracture Mr. Lawrence alluded to was caused by the plate having been insecurely attached to the pulley frame.

Mr. A. L. STEAVENSON thought the extreme importance of the subject was the only excuse for entering into a discussion upon the merits of rival inventions, and he thought that much good would ensue if the matter was thoroughly sifted and all the facts brought before the members, who then could exercise their own judgment in adopting, or not, any of the various suggestions brought forward; but for the Institute to be asked to express an opinion as to the relative merits of a hook was what it should not undertake, and therefore those gentlemen present who represented the different hooks must understand that the Institute could not carry the matter much further. He himself had for many years used Walker's hook, which had always acted very well. Even within the last week the engineman at one of the pits had moved the engine the wrong way, and the cage was safely disengaged. He thought that extreme simplicity was imperative, and that no hook could be considered in any way perfect that wanted that characteristic, and in this particular he certainly thought that the hook of Mr. Walker was the most perfect.

Mr. W. LISHMAN said, he perfectly agreed with Mr. Steavenson that the Institute should not recommend this, that, or the other hook; but it was of very great importance that they should, if possible, ascertain which was the best hook irrespective of who was the maker of it. For upwards of twelve years he had used Ormerod's hooks, and had now some twelve or fourteen pairs of them at work, and he had never found any one of them to act at the wrong time, or not to act when they should act. On one occasion they certainly saved life. Two men were in the cage; the cage was taken up to the pulley, and had this hook not been on, the men would in all probability either have gone over the pulley or they would have gone to the bottom of the pit. The President had mentioned the increase in the number of overwindings; that might or might not be. He thought that if it were so, it was to a very great extent the fault of the managers of collieries themselves. He himself had a rule, that if a man took up the cage to the pulley so that he undid his hook, he was fined a sovereign or lost his place. He thought a check of that kind quite sufficient to prevent any carelessness which might otherwise arise. The President also spoke of the necessity of having the framing sufficiently strong to resist the action of the hook; this of course must be done otherwise the apparatus would be of no use whatever. Mr. Forster spoke about having keps to arrest the cage in the event of the chains breaking as had been suggested. He was afraid this would rather multiply the elements of danger. In a simple hook there was only the element of danger due to the construction of the hook itself, whereas the introduction of additional catches increased

the number of parts which might go wrong. He did not think any hook could be reckoned to be absolutely safe as some gentlemen imagined; neither did he believe that any machinery could be perfect as to be entirely free from the possibility of accident; but still he believed that no pit should go without a safety-hook of one kind or another, at the discretion of the manager. Some objected to hooks in deep pits, and some on account of their falling down on the cage tops during the changing of the tubs, but he had talked with several colliery viewers who had deep pits, and who said they did not find the slightest inconvenience from the use of them.

Mr. WEEKS said, he was sorry he could not agree with the last speaker in condemning the keps suggested by the President and Mr. Forster. He had listened to the discussion both to-day and also on the former occasion with a great deal of interest, and he thought the only valuable suggestion he had heard was that of the President. Indeed if in practice there was anything like a drop of 7 feet 6 inches after the hooks came into operation (which he very much doubted)—or even a very much smaller drop incidental to the action of some of the hooks, he thought additional keps were an absolute necessity, as no chain could stand such shocks as these falls would cause, unless the cage chains used were of much greater strength than they usually were.

Mr. MORISON quite agreed with Mr. Weeks. He thought a fall of 7 feet 6 inches could never take place; if it did, neither the keps recommended by the Chairman, nor two or three others would arrest the fall of the cage.

Mr. ROSS said, with respect to the remarks which had been made about keps, he had made a rough calculation, and found that at a speed of twenty miles an hour, the cage would rise 14 feet after becoming suddenly disconnected from the rope; consequently it would have that much fall; and he did not think chains could be put on which would resist such a fall. He himself had had some experience with passenger hoists, and he knew that the keps alluded to acted with unerring certainty, especially so, in one case, which affected the lives of a large number of persons. The keps he alluded to sprung out when the cage had attained its highest position to which it might rise, and produced no shock on the chains.

Mr. WILLIS said, that the kind of catches to which the President had referred were additional keps placed immediately under the pulley wheels. These were used at the collieries belonging to the Messrs. Joicey, and at Washington, in which latter place they had been used for fourteen

or fifteen years without safety-hooks, and where he knew that on two occasions they had saved life.

Mr. MORISON asked if Mr. Willis had seen a cage run up anything like 14 feet, as named by Mr. Ross, or even 7 feet 6 inches ?

Mr. WILLIS—No. The only instance of overwinding he had ever seen was at a hematite mine in Lancashire, where they used an exceedingly cheap detaching-hook which they made themselves for a few shillings, and where the officials took a pride in practically showing the action of the safety apparatus to all who asked to see it.

Mr. LOGAN said, the catches had nothing to do with safety-hooks. He could not admit the possibility of a cage rising 14 feet, or even 7 feet 6 inches, after becoming disconnected. He had seen a large number of safety-hooks tried, and had seen the cage sent up at a very considerable velocity—hardly, perhaps, twenty miles an hour; but he never knew a cage rise more than 2 feet 6 inches, as far as he could measure with the eye. He believed that in all cases the hook got on the catch-plates before the cage began to descend. With regard to the matter of copper rivets he quite agreed with the remarks which the Chairman had made on that point.

The PRESIDENT said, with regard to the question which had been referred to by Mr. Steavenson and Mr. Lishman, it was perfectly clear that every person who had used any given hook with satisfactory results for a number of years could speak as to its value, but it did not follow that there were not other hooks equally good, and he thought that members must come to the same conclusion, and this seemed to be just as far as they could go; for he did not think it was for the Institute to express an opinion as to which was the best.

Mr. D. P. MORISON said, that he desired to withdraw the remark he made at the last meeting, that Mr. Moore, the Government Inspector, had recommended the use of hooks, for he had since been given to understand that he did not recommend them.

The following paper "On Jefferson's Automatic, Free-falling, Hydraulic Boring Apparatus," communicated by Mr. ROBERT MILLER, was taken as read, and the meeting terminated.

JEFFERSON'S AUTOMATIC, FREE-FALLING HYDRAULIC BORING APPARATUS.

COMMUNICATED BY ROBERT MILLER.

THE art of boring to great depths has perhaps received more attention on the continent than in this country. The working out of coal seams in the outcrop portion of many districts here, compels more and more the search for the extension of the coal seams under the newer overlying Permian strata. The great depths to which many pits will have to be sunk render it advisable, not only for the purpose of proving a seam of coal, but for ascertaining the character of the intervening strata, to execute preliminary borings. When the intervening strata are known, the cost of sinking the shafts can be calculated to much greater exactitude.

Until within comparatively recent years the use of the spring-pole, with rigid iron rods, has been the principal method adopted in this country. The first improvement on this method was the invention of the sliding shears or jars by Von Oeynhausen in 1834. In 1845 Herr Kind invented a free-falling borer, set free by a sliding cap moved by the resistance of the water in the bore-hole. In 1847 Herr Fabian invented a free-falling borer, the tool being set free by a sudden and slight rotation of the boring rods. In 1855 a description of Messrs. Mather and Platt's rope boring apparatus was first published. In 1856 Herr Werner invented a combination of the mechanism of Kind's and Fabian's free-falling borer. In 1855 M. Degousée exhibited a free-falling borer at the Paris Exhibition, which depended for its action on a dead-weight bar, resting on the bottom of the bore-hole. In 1859 Herr Zobel, Boring Inspector to the Prussian Government, invented an improvement of Werner's apparatus, and with this apparatus the two deepest bore-holes in the world have been sunk. This is, up to the present, the best apparatus for use with solid rigid rods. Other modifications of Kind's and Fabian's apparatus have been invented by Romanovsky and Greifenhagen.

In 1827, and the next following years, rope boring seems to have been extensively practised, Jobard's fluted boring block having been then much used. In 1861 George Kolb invented an automatic rotating arrangement for rope boring. In 1868 Herr Sonntag invented two arrangements

for rope boring, introducing Kind's free-falling arrangement in the one, and Fabian's in the other; and in 1871 Herr Kleritj invented an automatic arrangement of Kind's free-falling apparatus, in which the rotation of the cutting tool is effected automatically after each blow.

In 1846 M. Fauvelle invented what is now generally called hydraulic boring, in which a stream of water is forced down hollow boring rods, and up on the outside, carrying the debris with it. With a similar object M. Lane invented, in 1852, a valve arrangement in the rods. In 1860 MM. Chaniots and Catelineau invented a so-called boring pump. Somewhat later Mortenson, a Danish mining engineer, carried on many borings on a modification of Fauvelle's principle. Since then, the most rapid strides appear to have been made with the Diamond Rock Drill. Most of the above apparatus are described in detail in a paper read by Mr. J. Clark Jefferson, before the Midland Institute of Mining Engineers in 1878. In this paper it is shown that the Diamond Rock Drill borings cost from two to three times as much as those by any other system, the process being about three times as fast; and the use of this system is disapproved of for depths approaching 2,000 feet, especially in the carboniferous strata, owing to the high cost, which averages £5 per foot.

Fauvelle pointed out the great advantage which his system would possess if the water could be forced down the outside, and up the inside of the boring tubes. The diminished velocity of the descending stream did not injure the sides of the bore-hole so much, by constantly washing out parts of the sides, and the greater velocity which could be given to the ascending current, enabled it to carry off larger pieces of debris. When the current ascends outside there is a large amount of fine material in suspension, and this may increase so much at the bottom of the bore-hole as to clog fast the rods.

During the last four years Herr Köbrich, the present Boring Inspector for the Prussian Government, has extensively used an arrangement of Fabian's free-falling borer, in which the rods are formed of hollow tubes, the stream of water being forced down the outside and up the inside of them. Not only has Herr Köbrich been able to bring up the largest pieces of debris broken off from the bottom of the bore-hole, which keeps the bottom constantly clear, and prevents waste of time and power in breaking the already broken debris into fine powder; but cores have been bored, and, directly they have broken loose, they have been carried at once by the ascending current to the surface. The loss of cores, as is well known, often occurs with the Diamond Rock Drill. The broken pieces of debris which are brought to the surface are often so

large that it seems in many cases superfluous to bore for cores. The rate of advance with this apparatus averages 10 yards per day, and its cost compares favourably with that of the cheapest of any of the other methods, averaging, for 1,600 feet in depth, about 30s. per foot. Köbrich's apparatus is exceedingly well suited for bore-holes under 1,000 feet in depth: it is not automatic however, and the work of throwing off the free-falling cutter is expensive for great depths. Mr. J. C. Jefferson, of St. John's Collieries, Wakefield, has endeavoured to remedy these defects, and in the apparatus to be described, which is perfectly automatic, the principle of Degousée's free-falling borer is adopted.

Referring to the drawings:—A A, Plate XLVI., is a so-called dead weight tube, which, during the actual boring operations, remains stationary, resting on the bottom of the bore-hole, being weighted or held down in position by the dead weight D D.

B B is the free-falling tube, carrying at its bottom end the cutter chisel or cutting tool C C, which is screwed into the bottom of the free-falling tube B B. The cutter shown in the drawing is broken in the centre (see Figs. 5 and 6) to allow of core boring. The outline of the core is shown by dotted lines in Fig. 6. The core must necessarily be bored of a smaller diameter than the inside of the dead weight tube, through which it passes, forced up by the water current. To bore the core small enough, the inner edges of the cutter (*a a*, Figs. 5 and 6) must project inside the dead weight tube as shown in Figs 5 and 6. In order to raise the cutter C to the full height of the stroke, without at the same time raising the dead weight tube A A, the latter is slotted through to the height required by the stroke (*i.e.* to B′ B′, Figs. 5 and 7.) Also to allow of an entrance for the current of water and the debris to the inside of the dead weight tube A A, the latter has two openings (D D, Figs. 5, 6, and 8) about 6 inches high and $1\frac{1}{2}$ inch wide, slotted out at right angles to the chisel blade. In order to prevent any liability of the lower end of the dead weight tube A A, below B′ B′, being bent out of shape, owing to the length of the slot in which the chisel moves, the edges (X X, Fig. 6) of the slot, have been bent outwards to fit into corresponding recesses slotted out on the inside of the chisel block. These recesses slide over the whole length of the outward edges X X.

E E are the boring rods made of hollow tubing $2\frac{1}{2}$ inches outside diameter. The two lowest, however, are of a larger diameter than the rest. The inside diameter of the lowest but one is equal to the outside diameter of the dead weight tube A A; and the outside diameter of the lowest is equal to the inside diameter of the free-falling tube B B. To

the lower end of the lowest of the boring rods the catches F F are attached, being provided with two side conical projections N′ N′, about which the catches can oscillate in bearings formed in two steel plates, P P, screwed on to the lowest boring rod E E (Figs. 2 and 2A). The lower ends of the catches F F are kept constantly pressed inwards by means of flat springs (S S, Figs. 1 and 8), attached to the lower ends of the lowest boring tube E E. The upper ends of the catches F F are consequently kept constantly pressed outwards.

R R are two steel plates which can be screwed in the most suitable position on to the outside of the dead weight tube. By altering the position of R R the fall of the free-falling tube and chisel can be regulated.

N N is a ratchet wheel, with inside teeth, which is prevented from sliding longitudinally up or down the boring rod E E by the muff M M, which is held down by the ring O O screwed to the boring rod E E (Figs. 3 and 4). The object of the muff M M is to prevent the downward current of water finding access between the boring rods E E and the dead weight tube A A. For this purpose the muff M M has two grooves turned on its circumference, in which two U or V rings of India-rubber are placed, so that the muff M slides water-tight against the inside of the upper end of the free-falling tube B B.

V V is a single spiral square steel thread (left-handed), fixed to the inside of the free-falling tube B B, and which fits in a slot or groove on the outside of the ratchet wheel N N (Figs. 3 and 4).

T T (Fig. 4) are two flat springs attached to the outside of the boring rod E E, and which engage with the teeth of the ratchet wheel N N.

Y Y (Figs. 2 and 3) are set screws, which prevent the lowest of the boring rods E E (which has a corresponding groove cut on the outside), from rotating independently of the free-falling tube B B. The lowest of the boring rods E E is attached to the next by a collar joint, which permits the lowest rod to rotate independently of the rest. These screws would perhaps be better replaced by a key about two inches long.

The free-falling tube is provided with two vertical slits placed opposite to each other, and which are covered on the outside by the plates K K (Figs. 1, 8, and 9).

The action of the apparatus is as follows:—Supposing that the free-falling tube is resting on the bottom of the bore-hole, and that the boring rods have reached the bottom of the stroke, as shown in Fig. 8. In this position the upper ends of the catches F F will be about one inch below the upper ends of the vertical slits in the free-falling tube just mentioned.

When the first inch of the upward motion or stroke of the rods has been completed, the upper ends of the catch F F, which are constantly pressed outwards, catch beneath the upper ends of the slits just mentioned (Fig. 8 and right-hand side of Fig. 1), and so the further upward motion of the boring rods E E raises the free-falling tube B B with the chisel C C.

During the boring operations the dead weight tube A A remains stationary, resting on the bottom of the bore-hole. When the boring rods E E have nearly reached the top of the stroke the catches F F, or rather the lower ends of the catches, come into contact with the two steel plates R R, which, on the further upward motion of the boring rods, forces the lower ends of the catches F F outwards, and draws the upper ends inwards, till the catches occupy a vertical position as shown on the left-hand side of Fig 1. The upper ends of the catches are now completely withdrawn from the slits in the free-falling tube, and this having no support, falls freely with the cutter to the bottom of the bore-hole. The up stroke is completed directly afterwards, and when the down stroke has been carried to within one inch of the end of the stroke, the catches F F come opposite the slits in the free-falling tube, the upper ends being forced immediately into the slits by the springs S S. The weight of the dead weight tube A A, and the attached weight D D, must be so great that the friction between the steel plates R R and the catches F F is insufficient to raise them.

Thus, during the up stroke of the boring rods E E, the free-falling tube B B is raised, and, immediately on reaching the top of the stroke, the free-falling tube with the cutter is set free, and falls to the bottom of the bore-hole; whilst the boring rods slowly descend to catch up the free-falling tube at the bottom of the stroke to raise it for a fresh blow.

By attaching the steel plates R R lower down on the dead weight tube the lift of the free-falling tube and cutter is lessened at pleasure.

The automatic rotation of the cutting tool after every blow will now be described.

During the up stroke no rotation of any part of the instrument takes place. During the whole phase of up and down stroke the boring rods E E do not rotate at all, except the lowest. When the up stroke has been completed, and during the free fall of the free-falling tube, the tendency of the left-handed spiral V V is to rotate the ratchet wheel in the opposite direction to that indicated by the arrows in Fig. 4. As the ratchet wheel is prevented from rotating in this direction by the flat springs T T, attached to the boring rods E E, the spiral V V, and consequently the free-falling tube B B to which it is attached, and the cutter

C C, must rotate in the opposite direction or in that shown by the arrows. When the free-falling tube has reached the bottom of the bore-hole, and as the boring rods E E slowly descend, the groove in the ratchet wheel N N, sliding down over the spiral V V, tends to rotate the ratchet wheel N N in the direction indicated by the arrows. As this is not opposed by the springs T T, the ratchet wheel is rotated in the direction shown by the arrows during the descent of the boring rods E E. The weight of the boring tube B B, combined with the fact of the cutter C C being slightly embedded in the bottom of the bore-hole, obviates any liability of the tube B B rotating during the descent of the rods E E. Thus, during the up stroke, no rotation whatever takes place; during the free-falls of the tube B B it is rotated in the direction indicated by the arrows; and during the descent of the boring rods E E the ratchet wheel N N is rotated in the direction indicated by the arrows.

By having two or three screw holes (Z Z, Fig. 7) in the free-falling tube B B, the pitch of the spiral V V, and consequently the amount of rotation of the cutter C C after every stroke can be altered.

From the above it will be seen that the action of the boring apparatus is perfectly automatic.

The stream of water descends on the outside of the tube and rises to the surface in the inside with such a velocity as to raise even the largest pieces of rock which are chipped off by the cutter.

The Plate shows a design for an apparatus for boring an eight inch bore-hole with a $1\frac{3}{4}$ inch core. The inside diameter of the boring rods is 2 inches and the outside $2\frac{1}{2}$ inches. Hence the relative area of the cross section of the ascending stream of water is to that of the descending stream of water, as $2^2 : (8^2 - 2\frac{1}{2})^2$ or as $4 : (64 - 6\frac{1}{4})$ or say as 1 to 14, and the relative velocities of the descending stream and ascending stream will be as 1 to 14. A velocity of the ascending stream of 4 feet per second is sufficient to bring up the largest pieces of debris, hence the velocity of the descending stream need not exceed 3 to $3\frac{1}{2}$ inches per second, and the consumption of water 5 cubic feet per minute. When boring with a flat chisel the boring can be continued uninterruptedly until the chisel becomes blunt.

Although the above design has not been actually tried, since it is really only a combination of methods which have been in actual use, the inventor believes it would be found cheaper than any existing methods, and second only to the Diamond Rock Drill in speed. It is not patented.

To illustrate a paper communicated by Mr. Robert Miller
Hydraulic Boring Appar

FIG. 1.
CENTRE PART.

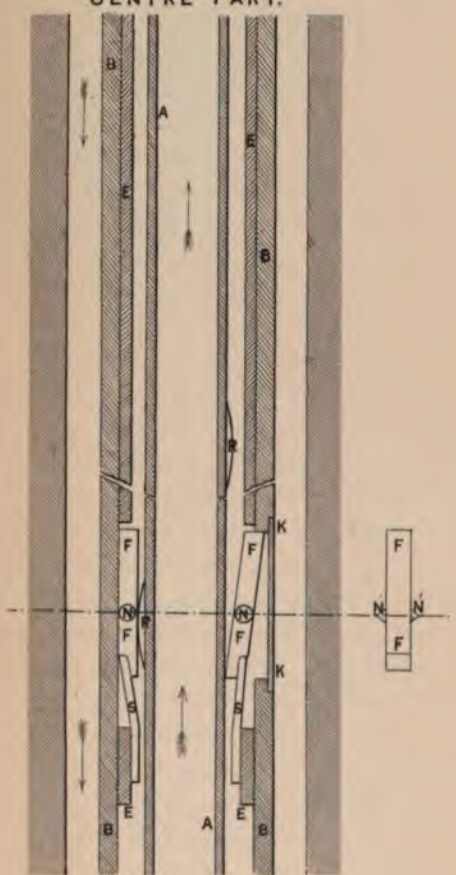


FIG. 3.
TOP PART.

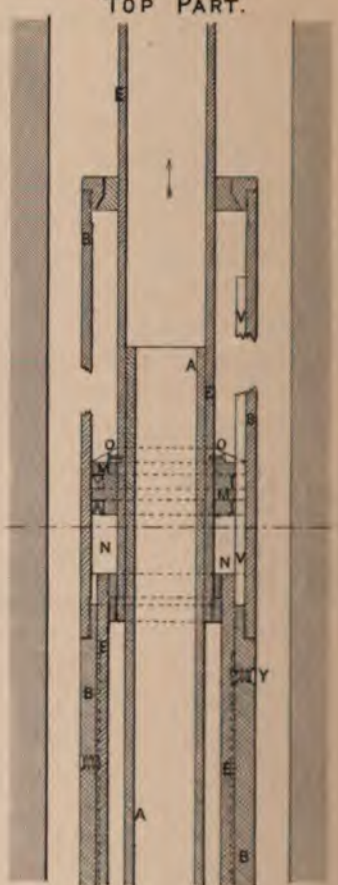


FIG. 2A.

FIG. 2.

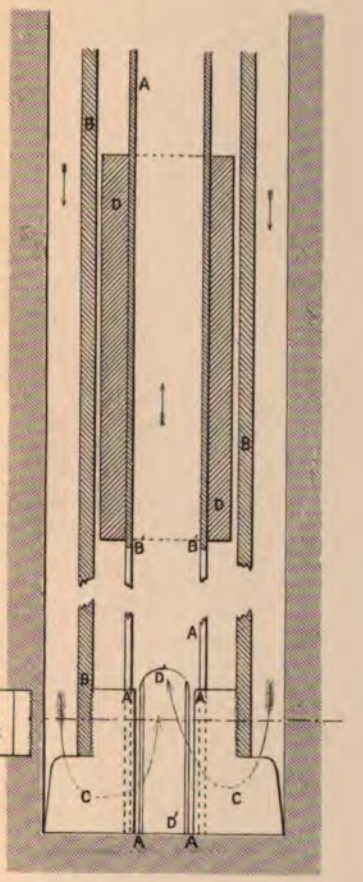
FIG. 4.

Proceedings No. 1 of M.S.M.E. 1879-80.

Pearson's Automatic Free falling

FIG. 5

BOTTOM PART.



G. 7.

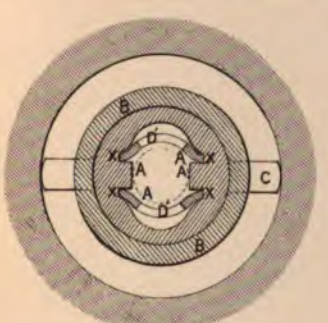
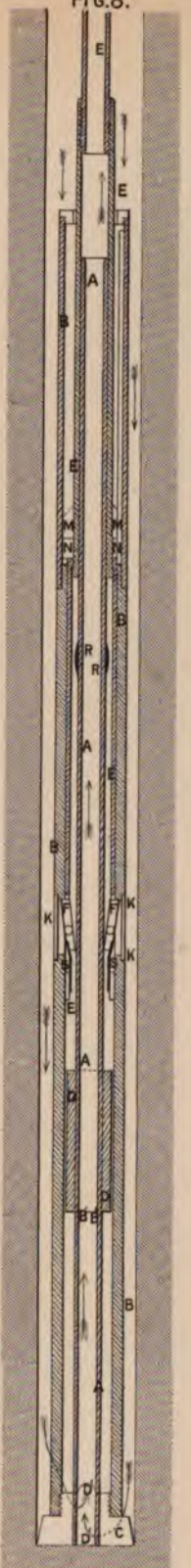
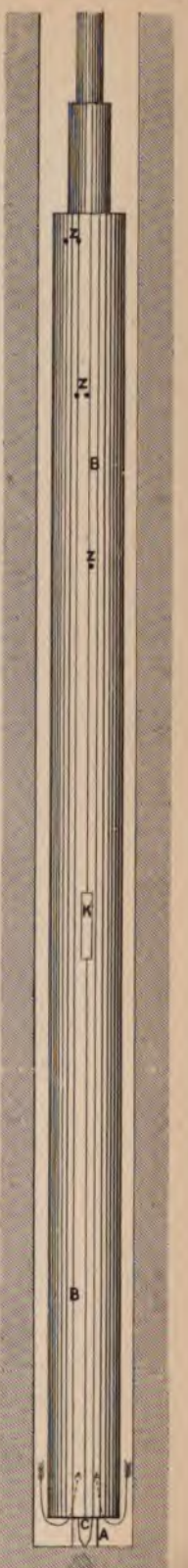


FIG. 6.

FIG. 8.





Ann. Reid Newcastle

PROCEEDINGS.

ANNUAL GENERAL MEETING, SATURDAY, AUGUST 7TH, 1880, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

G. C. GREENWELL, ESQ., IN THE CHAIR.

Messrs. William Green, Thomas Heppell, F. Coulson, and R. F. Boyd were appointed scrutineers to examine the voting papers for the election of officers for the year 1880-81.

The SECRETARY read the minutes of the last meeting and reported the proceedings of the Council.

The SECRETARY also read the reports of the Council and Finance Committee, which were unanimously adopted.

The following gentlemen were then elected :—

ORDINARY MEMBER—

Mr. GEORGE BARKER, M.E., Tay Iron Works, Perth.

ASSOCIATE MEMBERS—

Mr. THOMAS AUDUS, Mineral Traffic Manager, N.E. Railway, Newcastle-upon-Tyne.

Mr. JAMES FAIRLEY, Colliery Manager, Craghead and Holmside Collieries, Chester-le-Street.

The following were nominated for election at the next meeting :—

ASSOCIATE MEMBER—

Mr. R. W. COOPER, Solicitor, Newcastle-upon-Tyne.

STUDENT—

Mr. WM. THOMAS CURRY, Wardley Colliery, Newcastle-upon-Tyne.

The following paper, "On Rapid Sinking," by Mr. Henry Hall, one of H.M. Inspectors of Mines, was read :—

RAPID SINKING.

By HENRY HALL, H.M. Inspector of Mines

The following particulars of the sinking of two coal shafts to a depth of 360 yards at the Hindley Field Colliery, near Wigan, are perhaps worthy of being recorded in the Transactions of this Institute, because they exhibit the remarkable difference that exists in the character and cost of winning coal in particular coal-fields as compared with others. It is also believed that this "sinking" progressed to completion at a speed which has seldom, if ever, been surpassed.

It must be stated at the outset that the strata passed through consisted principally of shales, entirely free from water, and presenting few obstacles likely to retard the sinker; but the whole depth of the pits had to be excavated by means of gunpowder with the exception of ten yards at the surface and a few yards at three different points where the shafts passed through upper coal-seams which had already been worked to neighbouring pits; but any advantage that might have been gained from this circumstance was lost through the increased difficulty in making the sides of the pits safe, more care and work being needed to insure the bricking being secure and strong.

The following narrative has been kindly supplied by Mr. Robert Grundy, the manager of the Hindley Field Collieries, and under whose superintendence the operations were carried out:—

The first sod at No. 1 shaft was cut on June 11th, 1877, and the stone head reached in nineteen days at a depth of 10 yards. Whilst this work was in progress, a straight-linked horizontal single engine, of the following dimensions, was fixed, namely:—cylinder 14 inches diameter, stroke 3 feet, fly-wheel 9 feet, cylindrical drum 6 feet diameter, and geared two-and-a-half to one. This engine was fitted with two foot-brakes, one attached to the fly-wheel and the other to the drum, as a precaution in case of any breakage of the spur wheels.

For the first 150 yards of the sinking, steam at a pressure of 65 lbs. was supplied by a locomotive brought alongside the pit, and afterwards from two boilers of the Lancashire pattern.

The rope was of steel $\frac{7}{8}$-inch diameter, with a balance-weight bolted to the capping, and a swivel attached to take the spin out. The pulley was 12 feet diameter, and raised 40 feet above the surface. The hoppet or kibble weighed, when empty, $4\frac{1}{4}$ cwts. and carried a load of 1 ton.

The sinking from the stone head in No. 1 shaft, 10 yards from the surface, commenced on the 17th August, 1877, and on the 8th June, 1878, this pit had reached the Arley Seam at a depth of 354 yards, having occupied in sinking, bricking, and completing, 253 working-days, or 4·14 feet per working-day of twenty-four hours; the whole period of time that elapsed between commencing at the stone head and finishing being 296 days inclusive of Sundays, when work was suspended.

The size of this shaft when completed was, for the first $4\frac{1}{2}$ yards from the surface, 15 feet 6 inches, and the remainder 14 feet diameter (see Plate XLVII). The walling was 18 inches down to a depth of 13 feet 6 inches, and 9 inches thence to the bottom, and composed of ordinary bricks set in mortar. It was carried on oak and elm rings 10 inches wide by 3 inches thick, eight segments making the complete circle, and jointed together by placing an additional segment over each joint and making them fast with iron bolts, a bed being levelled for each ring which varied from 9 to 20 yards apart, and the size of the shaft reduced so as to leave solid earth for 3 feet under the ring in a slanting direction, this earth being afterwards partly dressed off when the bricking was put in, so that finally the rings rested on $5\frac{1}{2}$ inches of solid earth and $4\frac{1}{2}$ inches of brickwork.

The sinking of the second or upcast shaft progressed much more rapidly than No. 1; it is believed at a speed hitherto unequalled for a pit of similar size.

Mr. Grundy states:—The sinkers commenced at the stone head in No. 2 on the 9th August, 1878, and finished on the 5th April, 1879, having sunk a depth of three hundred and fifty yards. During this period the sinking was suspended for twenty-three working days in order to cut through in the Yard Coal Seam for ventilation; thus the sinking, walling, and completing of three hundred and fifty yards only occupied one hundred and eighty-three working days, or an average of 5·73 feet excavated and walled during each twenty-four hours.

The dimensions of this second or upcast shaft were as follows:—15 feet 6 inches to a depth of $6\frac{1}{2}$ yards, and 12 feet 3 inches diameter thence to the bottom. The brickwork was similar to No. 1 shaft, but carried on

cast-iron rings 10 inches wide by $1\frac{1}{4}$ inch, in place of timber, eight segments to the circle, and made fast together by means of flanges and bolts, a wooden liner being placed in each joint. The same winding engine, scaffold, jetty, and all other tackle, were used as in No. 1.

For the sinking of both pits, a runner or jetty, A, was used to receive the material as it was sent to the surface, its dimensions being 10 feet by 7 feet, and carried on three pairs of wheels each twelve inches diameter, travelling on flat-bottomed rails 21 feet long, and weighing 45 lbs. per yard, supported upon two pitch-pine logs 18 inches square and 45 feet in length. These rails were canted a little in favour of the full load so that the "runner" could be readily moved by hand.

The scaffold used was a winged draw-bar scaffold B, 9 inches less in diameter than the finished shaft; the framework, C, being of oak, 5 inches by 6 inches, and covered with 2-inch red wood deals. The hinges of the wings, D, passed in one length over the whole width of the scaffold and were bolted through the deals and framework by $\frac{5}{8}$-inch bolts. There were four slide-bars, E, attached, $2\frac{1}{2}$ inches square and 4 feet 3 inches long; four rings F, 7 inches diameter, made of $1\frac{1}{2}$ inch round iron; and four chains 11 feet 6 inches of $\frac{5}{8}$-inch iron, were added for the purpose of lifting the scaffold, which was always raised by means of the winding engine, and it could be sent down or taken out of the pit at any time in three or four minutes.

When bricking commenced the scaffold was on the bottom, and when the work had progressed to about 6 feet high it was gently stretched up by the winding engine to a little above the completed brickwork, and the drawbars then forced out till they had at least 9 inches of support.

Six seams of coals were sunk through, viz., the Wigan, 5 feet; Wigan, 4 feet; Wigan, 9 feet; King and Queen, Raven and Arley—the upper three of which had already been worked, and there was in consequence partial subsidence at these points amounting in all to about 25 yards; the fractures extending to a distance of eight or ten yards above the position of the seams. The precise depth to each seam was known, and immediately the strata was found to be broken the scaffold was lowered, holes drilled in the nearest solid rock above the broken ground, and fourteen iron plugs C inserted to carry a ring for brickwork, and in each case a ring was levelled for and fixed on the thill of the wrought seams.

Ventilation was supplied by means of ordinary canvas bratticing, carried on cross timbers 9 feet apart, these cross timbers being spiked to perpendicular ribs made fast to the walling by iron holdfasts, and giving a downcast space of 13 feet, the air returning through the open shaft.

Safety-lamps were used for examining the shafts after any cessation of work and whilst passing through the goaves where the wrought seams were met with. At these points a considerable quantity of fire-damp was given off, and openings had to be left in the walling to give it an outlet, care being taken that no open light should come in contact with it.

No. 2 shaft was sunk by contract, after reaching a depth of 30 yards, at the average price of 95s. per yard, for walling, sinking, and furnishing, paid as follows:—1st 110 yards, 85s.; 2nd 110 yards, 95s.; 3rd 110 yards, 105s.—the contractors finding powder, fuses, banksmen, tippers, and drivers; and the owners finding two ponies, pick and drill sharpeners, and enginemen.

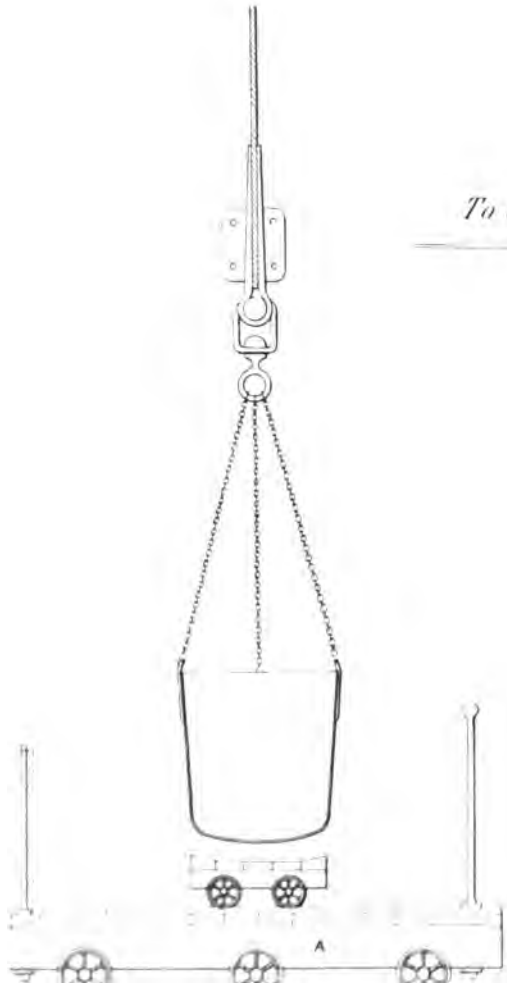
Gunpowder was the only explosive used with the exception of a few shots of dynamite.

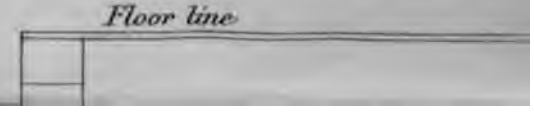
Both shafts are perfectly perpendicular, and show no signs of inferior workmanship.

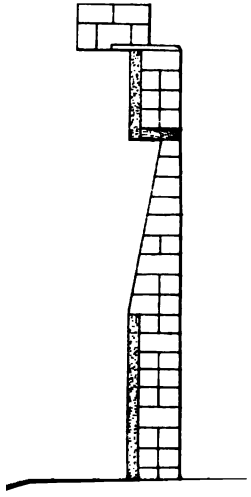
No accident, either fatal or otherwise, occurred during the whole of the operations.

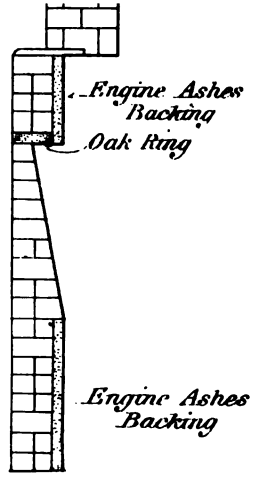
Mr. Grundy, who in the unavoidable absence of Mr. Hall, kindly attended to give any explanations that the meeting required, stated that the nature of the strata passed through would be better understood by the aid of Plate XLVIII. where they were fully described. It would be seen that there were upwards of 280 yards of shale, which was called metal, and about 80 yards of rock, and they put the crib in nearly every case upon the metal. In answer to questions from different members, Mr. Grundy said that the pit had been reduced in diameter after the first 4½ yards, to enable them easily at any time to arch it over, and to be able effectually to stop it up, if necessary, from accidents occurring in the workings. The brickwork at top was strengthened with a strong cast ring as an additional security against the headgear, which was of very great weight, bulging out the edge of the pit. The position of the permanent cribs and the mode of supporting them, together with the mode in which the brick interior of the shaft was permanently finished would be seen by reference to Plate XLVII. There were no pumps required as the pit was perfectly dry. The No. 2 Pit, which was sunk by contract, cost £4 a fathom less than No. 1, and took 30 per cent. less time and fewer men to sink. When they came to broken

To illustrate Mr. Henry Hall's paper "On rapid Sinking."









XLVIII.

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illustrate Mr Henry Hall's pap

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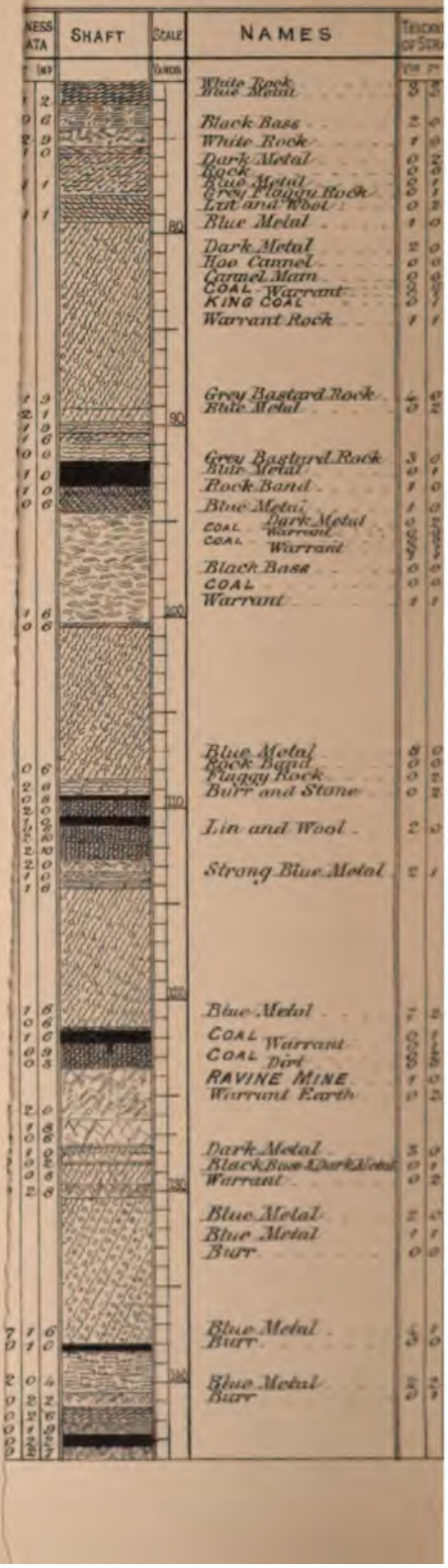

Rapid Sinking."

T, HINDLEY FIELD COLLIERY.

Scale Yards	Names	Thickness of Strata Yds	Ft	Ins
	Strong Blue Metal	5	1	0
	Strong Blue Metal	2	0	0
	COAL 9" Dirt 1" COAL 1'11"	0	2	9
150	Dirt	0	2	7
	YARD MINE	0	2	4
	Warrant	2	0	8
	Strong Blue Metal	1	2	9
	Lin and Wool	2	0	0
	Grey Rock	0	2	10
	Flaggy Rock	1	0	0
160	Burr Rock	0	1	6
	Lin and Wool	1	0	0
	Grey Rock	0	2	0
	Blue Metal	1	0	6
	Grey Rock	1	1	6
	Grey Burr	0	1	8
	Grey Rock	0	2	7
	Brown Burr	0	2	1
	Grey Rock	2	1	11
170	Flaggy Rock	0	2	9
	Grey Burr	0	2	1
	Strong Blue Metal	3	1	3
	Strong Blue Metal	1	1	6
	Iron Band	0	0	3
	Strong Blue Metal	0	2	3
	Dark Metal	0	1	7
	Dark Blue Metal	1	1	5
180	Blue Metal	3	1	0
	Strong Burr	0	0	8
	Flubbishy Coal	0	0	4
	Bastard Rock	1	1	8
	Grey Rock	2	0	0
190	Blue Metal	5	0	6
	COAL	0	0	6
	COAL Dirt	0	0	2
	Warrant	1	1	8
	Rocky Warrant	1	0	10
	Grey Rock	0	1	6
200	Strong Metal with Bands	6	1	8
	COAL	0	0	6
	COAL Dirt	0	0	2
	Warrant	0	2	10
	Grey Rock	0	0	9
	Dark Metal	0	1	9
	Rock Band	0	0	3
	Blue Metal	0	1	7
	Grey Rock	0	0	10
	Strong Blue Metal	3	1	0
	Blue Metal	0	2	2
	Grey Rock	0	0	7
210				
	Lin and Wool	5	0	7
	Strong Blue Metal	1	1	1
	Grey Rock Mixture	0	0	10
	COAL	0	0	2
	Rock Warrant	1	0	0

Scale Yards	Names	Thickness of Strata Yds	Ft	Ins
	Bastard Rock	1	2	11
220				
	Strong Blue Metal Iron Bands	3	2	8
	COAL	0	0	6
	Warrant Earth	0	1	0
	Blue Metal	0	2	9
	Blue Metal	3	2	6
230	Grey Rock	3	2	0
	Burr Rock	0	1	6
	Grey Rock	0	2	6
	Blue Metal	1	2	0
	Cockle Shell Bed	0	1	0
	Blue Metal	1	2	7
	Blue Metal	0	2	3
	Lin and Wool Rock Bands	2	0	2
240	White Rock	1	0	8
	Lin and Wool	2	1	9
	Blue Metal	1	2	7
	Lin and Wool	1	1	9
	White Rock	0	2	10
	Lin and Wool	1	1	4
250	Lin and Wool	2	0	0
	Blue Metal with Iron Bands	8	0	10
	Dark Metal	0	2	9
260	Blue Metal	0	2	11
	Grey Rock	1	1	2
	Lin and Wool	0	2	10
	Lin and Wool / Burr Rock	0	0	6
	Grey Rock / Burr Rock	0	0	6
	Grey Rock / Grey Rock	0	1	2
	Strong Grey Rock / Strong Grey Rock	0	2	8
	Flaggy Rock	1	0	8
270	Lin and Wool	1	2	8
	Blue Metal	7	2	1
	Dark Metal	0	2	8
	ARLEY MINE	1	0	7
	White Warrant	1	0	10
280	Lin and Wool	0	2	6
	Blue Metal	6	2	7
	COAL	0	0	2
	Dark Warrant	0	2	3

Arch Rock Newcastle

ground they lowered the scaffold and drove the iron plugs in as shown at A, Plate XLVII., and they let the ring rest there till they got through the worked-out seam; they then put another ring on the thill and proceeded. Some difficulty was experienced whilst doing this, from the stone and coal falling, but by going slower and using increased care all accident was avoided. They were much troubled with gas in passing through these goafs, and obliged to use safety-lamps, which somewhat retarded the work; and they got upwards of 10,000 tons of coal out of No. 1 Shaft while the men were sinking No. 2. Natural ventilation alone was required.

Mr. WILLIAM COCHRANE said he had great pleasure in proposing a vote of thanks to Mr. Hall for his valuable paper, and to Mr. Grundy for his kindness in attending the meeting to explain the details; Mr. T. J. Bewick having seconded the motion, it was unanimously carried.

After the meeting was over Mr. D. P. Morison exhibited and explained a new form of Indicator, in which a curved hollow tube was substituted for the ordinary cylinder, and the pressure indicated in the same way as with a Bourdon gauge.

APPENDIX.

BAROMETER AND THERMOMETER READINGS FOR 1879.

BY THE SECRETARY.

THESE readings have been obtained from the observatories of Kew and Glasgow, and will give a very fair idea of the variations of temperature and atmospheric pressure in the intervening country, in which most of the mining operations in this country are carried on.

The Kew barometer is 34 feet, and the Glasgow barometer 180 feet above the sea level. The latter readings have been reduced to 32 feet above the sea level, by the addition of ·150 of an inch to each reading, and both readings are reduced to 32 degrees Fahrenheit.

The fatal accidents have been obtained from the Inspectors' reports, and are printed across the lines, showing the various readings. The name of the colliery at which the explosion took place is given first, then the number of deaths, followed by the district in which it happened.

At the request of the Council the exact readings at both Kew and Glasgow have been published in figures.

BAROMETER READINGS, &c.

JANUARY, 1879.

KEW.							GLASGOW.						
Barometer.					Temperature.		Barometer.					Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	29·701	29·826	29·656	29·418	50·9	34·6	1	29·408	29·667	29·708	29·726	40·0	24·7
2	29·634	30·038	30·116	30·011	33·1	28·6	2	29·774	29·832	29·802	29·765	36·3	24·1
3	29·690	29·327	29·439	29·547	42·1	29·8	3	29·628	29·520	29·453	29·484	32·1	24·5
4	29·609	29·723	29·767	29·979	38·8	31·2	4	29·540	29·699	29·834	29·914	36·9	28·1
5	30·088	30·130	30·104	30·133	36·9	26·0	5	29·948	29·994	30·022	30·101	36·0	25·5
6	30·193	30·236	30·223	30·183	31·7	22·9	6	30·152	30·178	30·116	30·091	35·2	21·7
7	30·134	30·052	29·892	29·762	34·9	28·2	7	30·002	29·939	29·797	29·703	35·8	26·1
8	29·646	29·576	29·619	29·833	33·7	28·0	8	29·670	29·768	29·888	30·054	34·8	25·0
9	29·984	30·023	29·973	29·855	33·9	27·0	9	30·146	30·066	30·002	29·880	36·2	24·9
10	29·710	29·658	29·574	29·561	29·1	23·9	10	29·800	29·752	29·650	29·604	31·5	28·0
11	29·540	29·564	29·625	29·740	26·4	22·5	11	29·585	29·642	29·684	29·765	31·9	22·5
12	29·889	30·079	30·166	30·168	33·7	20·7	12	29·817	29·906	29·829	29·680	35·0	17·8
13	30·066	30·050	30·126	30·156	45·3	31·0	13	29·604	29·721	29·842	29·899	42·1	33·8
14	30·075	29·952	29·783	29·596	45·9	30·0	14	29·782	29·532	29·448	29·384	45·2	37·9
15	29·528	29·664	29·801	29·937	46·1	34·5	15	29·324	29·438	29·594	29·744	40·0	34·2
16	29·919	29·910	29·905	30·061	37·9	25·5	16	29·798	29·906	29·985	30·068	37·9	27·8
17	30·145	30·226	30·179	30·149	34·1	28·0	17	30·096	30·110	30·101	29·868	38·4	19·8
18	30·005	29·944	29·984	30·134	35·1	33·0	18	29·780	29·878	30·050	30·186	38·2	33·1
19	30·226	30·305	30·328	30·336	34·7	29·0	19	30·250	30·290	30·268	30·281	36·7	27·0
20	30·284	30·233	30·102	30·012	31·1	27·9	20	30·222	30·155	30·020	29·969	28·2	21·9
21	29·914	29·920	29·887	29·935	30·7	26·6	21	29·956	30·005	30·049	30·137	35·0	24·0
22	29·932	30·011	29·985	30·005	31·3	26·9	22	30·169	30·206	30·182	30·205	32·0	26·9
23	29·967	29·990	29·978	29·968	31·2	25·1	23	30·154	30·156	30·099	30·102	31·3	27·4
24	29·972	29·990	29·969	30·002	31·4	29·1	24	30·068	30·122	30·103	30·153	28·5	19·3
25	30·011	30·035	30·052	30·075	32·3	28·9	25	30·159	30·179	30·143	30·139	29·7	18·4
26	30·092	30·152	30·185	30·256	34·7	32·0	26	30·096	30·153	30·183	30·286	32·4	23·0
27	30·297	30·378	30·386	30·400	35·0	33·8	27	30·319	30·396	30·408	30·435	34·2	25·3
28	30·376	30·334	30·255	30·224	34·4	31·8	28	30·374	30·338	30·435	30·214	38·9	23·8
29	30·206	30·242	30·230	30·242	34·5	31·0	29	30·437	30·352	30·390	30·414	34·9	31·5
30	30·241	30·280	30·261	30·273	34·5	31·7	30	30·386	30·406	30·362	30·347	35·0	32·4
31	30·266	30·282	30·207	30·178	32·6	30·0	31	30·321	30·304	30·215	30·172	34·1	32·3

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1	30·104	30·080	29·953	29·882	31·7	28·9	1	30·102	29·943	29·830	29·880	32·0	26·4
2	29·769	29·747	29·712	29·687	40·9	30·8	2	29·782	29·744	29·700	29·714	34·0	30·0
3	29·609	29·562	29·571	29·685	38·2	33·0	3	29·714	29·785	29·804	29·890	35·0	33·3
4	29·803	29·945	29·982	30·022	36·9	33·5	4	29·945	29·992	29·926	29·850	36·4	33·0
5	30·017	29·931	29·752	29·649	40·0	32·1	5	29·664	29·490	29·339	29·437	40·6	34·4
6	29·559	29·519	29·496	29·614	49·3	40·0	6	29·030	28·912	29·061	29·178	44·9	40·5
7	29·574	29·374	29·245	29·220	49·9	43·0	7	29·083	28·978	28·922	28·932	47·2	40·0
8	29·335	29·502	29·543	29·523	51·5	42·8	8	29·042	29·122	29·190	29·280	42·0	35·0
9	29·289	29·330	29·308	29·141	52·3	47·0	9	29·486	29·111	29·088	29·063	36·8	32·4
10	29·059	28·917	28·815	28·859	50·5	45·5	10	28·982	28·904	28·803	28·790	40·7	36·3
11	28·935	28·989	29·036	29·188	50·3	43·8	11	28·833	28·954	29·109	29·306	39·7	31·6
12	29·394	29·632	29·793	29·897	44·0	36·5	12	29·466	29·620	29·690	29·783	36·5	31·2
13	29·881	29·775	29·587	29·489	42·6	38·5	13	29·748	29·650	29·503	29·494	37·2	31·6
14	29·429	29·471	29·481	29·566	48·9	43·0	14	29·490	29·599	29·628	29·637	39·2	35·9
15	29·573	29·592	29·465	29·305	43·2	39·7	15	29·539	29·434	29·242	29·104	39·7	35·9
16	29·047	29·065	29·068	29·097	44·1	36·5	16	29·038	29·044	29·033	28·997	36·5	33·0
17	28·987	28·965	28·964	28·983	42·8	32·9	17	28·935	28·916	28·913	28·984	36·9	32·9
18	29·054	29·146	29·233	29·319	42·2	32·5	18	29·065	29·170	29·206	29·272	34·1	27·8
19	29·361	29·436	29·394	29·223	43·9	34·0	19	29·248	29·198	29·144	29·098	32·1	26·2
20	29·073	29·091	29·051	29·129	42·5	33·9	20	29·068	29·079	29·096	29·149	33·8	25·7
21	29·085	29·104	29·220	29·274	37·7	30·5	21	29·182	29·202	29·201	29·226	35·1	25·8
22	29·300	29·327	29·334	29·440	35·3	28·6	22	29·238	29·322	29·385	29·484	34·9	27·3
23	29·487	29·527	29·487	29·618	34·2	30·3	23	29·510	29·628	29·678	29·758	39·0	31·0
24	29·705	29·775	29·816	29·964	36·6	30·8	24	29·749	29·804	29·955	30·107	38·0	28·3
25	29·991	30·000	29·917	29·919	36·0	27·7	25	30·153	30·186	30·170	30·202	38·4	25·0
26	29·951	30·023	30·051	30·097	36·2	33·4	26	30·178	30·147	30·038	29·967	38·6	23·4
27	30·028	29·977	29·867	29·791	38·0	30·4	27	29·860	29·806	29·678	29·585	44·9	38·0
28	29·710	29·702	29·676	29·723	46·1	37·1	28	29·603	29·655	29·671	29·782	44·7	32·2

BAROMETER READINGS, &c.

MARCH, 1879.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	29·832	29·979	30·050	30·150	46·4	35·0	1	29·883	29·978	29·950	29·825	42·0	29·9
2	30·158	30·168	30·074	30·036	47·9	25·7	2	29·726	29·768	29·518	29·580	44·7	39·0
3	29·940	29·884	29·893	30·012	45·7	30·7	3	29·436	29·500	29·672	29·626	40·4	33·1
4	30·075	30·082	30·054	30·055	47·9	32·5	4	29·562	29·468	29·440	29·502	48·1	36·2
5	30·030	30·031	29·952	29·934	52·2	44·2	5	29·482	29·406	29·445	29·476	50·1	40·8
6	30·059	30·192	30·209	30·318	53·7	35·8	6	29·706	29·952	29·898	30·043	46·4	38·0
7	30·399	30·503	30·514	30·565	55·0	32·0	7	30·195	30·344	30·410	30·476	49·7	39·8
8	30·588	30·575	30·473	30·456	56·8	29·1	8	30·468	30·412	30·310	30·250	50·9	36·6
9	30·404	30·446	30·383	30·425	59·8	29·4	9	30·140	30·150	30·150	30·140	48·8	42·2
10	30·408	30·410	30·291	30·234	54·9	36·1	10	30·100	30·084	29·996	30·051	47·1	37·8
11	30·156	30·319	30·340	30·342	48·3	43·0	11	30·146	30·138	30·198	30·122	44·3	33·1
12	30·208	30·051	29·903	30·101	54·7	37·2	12	29·758	29 632	29·991	30·218	49·7	30·7
13	30·261	30·358	30·300	30·276	43·3	30·3	13	30·259	30·258	30·260	30·258	39·0	24·3
14	30·225	30·209	30·081	29·969	39·8	32·0	14	30·220	30·168	29·985	29·790	31·7	21·3
15	29·850	29·798	29·667	29·641	49·9	39·1	15	29·548	29·493	29·458	29·521	33·7	27·7
16	29·618	29·688	29·746	29·876	53·9	42·9	16	29·600	29·726	29·842	29·972	37·1	30·1
17	29·987	30·080	30·059	30·043	45·7	36·0	17	30·009	30·032	29·918	29·835	36·6	30·5
18	29·941	29·874	29·758	29·710	51·9	37·5	18	29·783	29·765	29·680	29·647	39·3	33·8
19	29·674	29·715	29·679	29·732	63·7	41·2	19	29·650	29·744	29·802	29·900	43·6	36·0
20	29·726	29·785	29·733	29·816	54·1	42·1	20	29·922	29·955	29·954	29·974	39·2	36·8
21	29·796	29·834	29·775	29·741	44·9	38·7	21	29·932	29·921	29·863	29·924	45·3	34·6
22	29·690	29·745	29·745	29·780	39·1	35·2	22	29·990	30·066	30·054	30·078	37·7	31·9
23	29·780	29·820	29·815	29·852	37·5	33·0	23	30·082	30·132	30·127	30·144	39·0	32·8
24	29·837	29·855	29·824	29·834	33·8	30·5	24	30·112	30·118	30·089	30·124	35·0	31·6
25	29·799	29·799	29·740	29·711	33·7	29·7	25	30·075	30·023	29·920	29·896	34·9	31·5
26	29·671	29·652	29·611	29·598	35·9	32·4	26	29·832	29·840	29·818	29·822	36·9	28·6
27	29·545	29·547	29·523	29·567	40·9	33·0	27	29·776	29·770	29·742	29·748	36·1	26·9
28	29·594	29·682	29·714	29·729	44·4	31·6	28	29·700	29·666	29·521	29·348	39·0	28·4
29	trace.	29·643	29·659	29·782	57·1	38·2	29	29·350	29·358	29·450	29·457	51·1	35·4
30	lost.	29·727	29·656	29·652	52·9	38·4	30	29·333	29·255	29·266	29·295	50·5	39·0
31	29·602	29·610	29·591	29·622	53·5	43·0	31	29·289	29·339	29·325	29·338	48·8	37·8

APRIL, 1879.

1	29·617	29·665	29·604	29·623	51·9	42·0	1	29·328	29·472	29·500	29·560	51·1	39·0
2	29·606	29·610	29·545	29·544	53·9	37·5	2	29·538	29·526	29·490	29·522	49·5	34·9
3	29·521	29·556	29·568	29·646	52·9	33·0	3	29·517	29·534	29·514	29·544	48·9	30·9
4	29·710	29·794	29·783	29·845	54·7	34·0	4	29·555	29·596	29·594	29·606	49·0	37·5
5	29·823	29·794	29·708	29·647	54·3	41·2	5	29·548	29·462	29·364	29·300	50·1	44·3
6	29·575	29·435	29·276	29·187	51·4	42·5	6	29·208	29·156	28·974	28·946	49·8	41·6
7	28·949	28·918	28·962	28·989	59·2	45·2	7	29·020	29·024	28·928	29·000	47·0	38·9
8	29·054	29·207	29·288	29·382	57·4	45·0	8	29·076	29·120	29·226	29·381	48·0	40·8
9	29·399	29·406	29·446	29·511	53·4	42·0	9	29·461	29·586	29·671	29·794	40·9	38·7
10	29·555	29·674	29·806	29·958	47·4	35·5	10	29·882	30·002	30·062	30·173	43·8	35·5
11	29·999	30·081	30·052	30·075	41·3	31·0	11	30·162	30·184	30·104	30·074	48·1	35·0
12	30·004	29·913	29·762	29·653	42·2	28·4	12	29·973	29·940	29·877	29·813	42·0	31·7
13	29·583	29·620	29·604	29·626	46·9	33·0	13	29·760	29·794	29·820	29·852	39·3	30·3
14	29·552	29·519	29·488	29·511	44·4	34·2	14	29·770	29·732	29·663	29·680	40·6	32·9
15	29·472	29·483	29·442	29·481	57·2	35·2	15	29·636	29·629	29·572	29·573	42·7	35·4
16	29·456	29·504	29·511	29·569	45·4	38·0	16	29·515	29·504	29·450	29·502	49·5	30·9
17	29·567	29·616	29·646	29·761	49·0	34·4	17	29·540	29·653	29·706	29·824	45·1	34·5
18	29·827	29·876	29·880	29·919	46·5	33·2	18	29·866	29·919	29·878	29·885	47·0	30·7
19	29·909	29·869	29·731	29·624	52·9	30·9	19	29·830	29·780	29·646	29·610	50·5	31·8
20	29·440	29·363	29·341	29·379	54·9	38·1	20	29·522	29·490	29·466	29·508	42·1	37·4
21	29·392	29·433	29·478	29·555	44·9	39·2	21	29·508	29·562	29·566	29·602	49·0	34·8
22	29·548	29·557	29·520	29·505	50·7	33·7	22	29·558	29·520	29·507	29·498	43·7	38·4
23	29·443	29·424	29·424	29·499	54·1	41·5	23	29·460	29·474	29·492	29·593	46·9	37·4
24	29·567	29·751	29·922	30·071	53·9	44·0	24	29·668	29·828	29·958	30·030	44·7	38·7
25	30·090	30·063	29·948	29·775	56·9	35·0	25	29·972	29·866	29·696	29·592	45·7	36·1
26	29·710	29·688	29·617	29·582	60·1	42·0	26	29·556	29·545	29·532	29·596	53·6	40·4
27	29·567	29·618	29·634	29·780	59·0	43·0	27	29·674	29·762	29·846	29·949	45·2	41·7
28	29·843	29·927	30·011	30·146	52·1	40·0	28	30·012	30·122	30·186	30·253	49·9	39·1
29	30·223	30·288	30·286	30·271	51·5	35·4	29	30·248	30·252	30·238	30·246	51·3	38·1
30	30·207	30·203	30·167	30·143	50·5	40·0	30	30·210	30·216	30·164	30·184	47·8	37·0

BAROMETER READINGS, &c.

MAY, 1879.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	30·108	30·111	30·104	30·193	47·5	38·0	1	30·182	30·223	30·250	30·330	48·9	35·9
2	30·222	30·283	30·308	30·384	49·9	35·4	2	30·368	30·373	30·350	30·380	50·5	31·2
3	30·407	30·421	30·379	30·437	54·4	32·8	3	30·393	30·396	30·380	30·408	59·0	35·6
4	30·461	30·435	30·437	30·490	56·2	31·9	4	30·417	30·454	30·444	30·468	59·8	35·3
5	30·477	30·457	30·343	30·264	64·0	35·0	5	30·448	30·404	30·272	30·076	57·4	41·7
6	30·129	30·085	30·063	30·049	49·9	38·0	6	30·138	30·186	30·172	30·196	47·1	36·7
7	29·997	30·000	29·991	30·062	45·1	35·7	7	30·162	30·168	30·120	30·100	44·8	35·9
8	30·054	30·043	29·947	29·851	49·1	34·3	8	29·991	29·814	29·696	29·708	53·0	33·9
9	29·745	29·729	29·765	29·898	53·3	38·3	9	29·730	29·813	29·855	29·912	46·7	37·8
10	29·943	30·024	30·026	30·046	50·8	31·0	10	29·920	29·930	29·888	29·824	51·0	32·8
11	30·033	30·036	30·016	30·032	47·9	38·0	11	29·676	29·685	29·756	29·891	56·0	40·9
12	30·045	30·112	30·117	30·143	61·9	45·6	12	29·928	29·998	30·027	30·046	56·5	43·7
13	30·120	30·095	30·031	29·965	57·1	40·0	13	29·990	29·940	29·868	29·862	54·3	43·5
14	29·859	29·787	29·767	29·852	55·9	46·2	14	29·836	29·860	29·916	30·014	53·9	42·5
15	29·918	29·949	29·945	29·969	50·1	43·0	15	30·061	30·105	30·154	30·202	53·7	37·0
16	30·024	30·102	30·120	30·126	53·9	43·9	16	30·184	30·116	30·024	29·994	38·3	36·5
17	30·073	29·996	29·880	29·764	59·7	34·0	17	29·916	29·870	29·784	29·740	57·9	43·4
18	29·602	29·565	29·566	29·656	57·8	47·2	18	29·695	29·724	29·755	29·834	50·3	41·3
19	29·691	29·802	29·832	29·898	59·2	46·4	19	29·818	29·828	29·758	29·771	58·4	40·7
20	29·905	29·973	29·996	30·051	64·9	42·5	20	29·767	29·818	29·886	29·966	53·9	45·2
21	30·074	30·118	30·090	30·114	65·8	49·6	21	29·998	30·010	29·949	29·955	59·9	46·2
22	30·107	30·108	30·058	30·073	64·8	49·0	22	29·900	29·908	29·917	29·999	57·0	44·8
23	30·069	30·154	30·156	30·178	55·8	46·0	23	30·077	30·156	30·146	30·096	57·5	42·9
24	30·180	30·176	30·059	29·994	66·3	43·9	24	29·970	29·904	29·844	29·809	53·3	44·5
25	29·857	29·823	29·829	29·878	60·1	49·0	25	29·756	29·718	29·666	29·624	53·9	39·8
26	29·843	29·786	29·698	29·654	58·2	42·6	26	29·508	29·446	29·446	29·512	52·8	40·9
27	29·599	29·581	29·551	29·517	58·0	48·0	27	29·556	29·636	29·674	29·724	55·2	39·4
28	29·535	29·593	29·579	29·561	60·0	47·3	28	29.746	29·750	29·682	29·678	60·7	41·9
29	29·524	29·600	29·662	29·731	61·4	46·0	29	29·664	29·656	29·616	29·618	59·8	40·2
30	29·765	29·812	29·792	29·780	60·8	46·0	30	29·548	29·582	29·620	29·630	51·6	46·7
31	29·699	29·635	29·627	29·617	61·4	47·0	31	29·580	29·560	29·514	29·532	54·8	44·5

JUNE, 1879.

1	29·603	29·565	29·547	29·590	59·3	50·2	1	29·480	29·463	29·438	29·438	53·8	39·9
2	29·638	29·660	29·656	29·536	57·2	48·0	2	29·414	29·457	29·492	29·554	57·3	41·5
3	29·391	29·451	29·647	29·761	60·0	47·0	3	29·540	29·568	29·571	29·610	58·1	40·1
4	29·820	29·861	29·855	29·896	62·8	44·3	4	29·628	29·690	29·722	29·801	62·0	43·5
5	29·871	29·834	29·739	29·688	67·8	43·4	5	29·793	29·816	29·768	29·752	58·2	42·7
6	29·633	29·672	29·679	29·748	68·6	52·4	6	29·704	29·720	29·731	29·738	56·8	45·9
7	29·738	29·690	29·576	29·548	64·8	53·9	7	29·698	29·672	29·643	29·618	56·2	46·2
8	29·545	29·575	29·559	29·606	66·3	52·7	8	29·484	29·428	29·450	29·502	60·4	45·7
9	29·641	29·763	29·820	29·916	63·0	52·9	9	29·536	29·606	29·638	29·756	59·1	48·7
10	29·985	30·006	29·994	30·029	69·3	50·4	10	29·824	29·880	29·906	29·974	62·8	48·7
11	29·998	29·970	29·917	29·950	64·3	47·8	11	29·988	29·970	29·932	29·922	66·7	45·3
12	29·946	29·954	29·934	29·951	64·6	50·0	12	29·886	29·939	29·943	29·996	56·8	49·0
13	29·982	30·084	30·099	30·125	67·0	51·9	13	30·026	30·062	30·045	30·054	64·0	48·3
14	30·112	30·091	30·036	30·002	70·8	48·0	14	30·014	29·980	29·902	29·878	66·8	45·8
15	29·929	29·855	29·785	29·742	65·6	57·2	15	29·774	29·738	29·690	29·679	65·9	50·3
16	29·640	29·482	29·449	29·506	67·4	56·0	16	29·634	29·600	29·562	29·508	57·0	48·8
17	29·514	29·514	29·483	29·554	67·6	53·8	17	29·426	29·418	29·456	29·524	58·4	51·8
18	29·640	29·757	29·809	29·873	68·0	53·1	18	29·596	29·682	29·716	29·753	65·0	48·9
19	29·872	29·892	29·847	29·778	67·2	49·4	19	29·724	29·694	29·614	29·536	65·0	52·7
20	29·686	29·764	29·813	29·882	68·9	56·8	20	29·454	29·532	29·582	29·617	66·0	53·0
21	29·834	29·741	29·648	29·645	61·0	54·5	21	29·594	29·516	29·369	29·348	57·2	53·1
22	29·686	29·789	29·867	29·937	63·0	52·0	22	29·389	29·526	29·642	29·707	60·0	49·9
23	29·916	29·868	29·777	29·713	62·2	47·8	23	29·674	29·630	29·570	29·535	61·4	49·7
24	29·579	29·581	29·590	29·616	62·3	47·8	24	29·446	29·408	29·404	29·406	57·9	49·5
25	29·558	29·549	29·569	29·716	67·0	49·4	25	29·400	29·438	29·442	29·488	59·9	49·1
26	29·759	29·734	29·671	29·742	63·3	47·1	26	29·501	29·456	29·366	29·381	58·8	47·5
27	29·813	29·836	29·821	29·797	68·8	52·0	27	29·462	29·392	29·330	29·379	63·2	51·5
28	29·737	29·770	29·830	29·923	69·4	56·0	28	29·430	29·362	29·458	29·556	60·0	50·0
29	29·958	29·963	29·924	29·974	66·8	51·8	29	29·606	29·646	29·628	29·670	64·4	50·3
30	30·010	30·053	30·014	29·933	68·7	51·7	30	29·704	29·762	29·766	29·682	61·1	50·9

BAROMETER READINGS, &c.

JULY, 1879.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	29·651	29·394	29·323	29·385	63·0	54·0	1	29·458	29·138	28·941	28·917	58·9	49·7
2	29·436	29·562	29·600	29·593	64·2	51·2	2	28·907	29·007	29·066	29·138	51·9	47·9
3	29·540	29·424	29·397	29·524	58·5	51·5	3	29·134	29·156	29·184	29·209	58·3	48·3
4	29·565	29·633	29·694	29·776	64·4	49·4	4	29·234	29·357	29·476	29·539	56·0	49·6
5	29·794	29·847	29·848	29·908	62·6	50·6	5	29·566	29·634	29·678	29·762	58·5	48·6
6	29·915	29·937	29·920	29·836	62·3	49·5	6	29·782	29·779	29·726	29·550	62·5	48·3
7	29·725	29·696	29·623	29·629	70·2	56·0	7	29·436	29·436	29·362	29·225	60·7	50·0
8	29·544	29·464	29·383	29·425	61·2	51·2	8	29·040	28·983	28·928	29·046	60·3	50·5
9	29·419	29·458	29·516	29·594	61·3	52·0	9	29·138	29·292	29·390	29·540	62·3	50·9
10	29·642	29·743	29·828	29·900	64·2	52·4	10	29·636	29·728	29·764	29·824	60·5	48·9
11	29·927	29·954	29·941	29·910	64·4	48·1	11	29·836	29·857	29·838	29·802	56·7	47·5
12	29·835	29·754	29·668	29·559	61·7	53·6	12	29·726	29·698	29·644	29·634	57·0	46·5
13	29·497	29·480	29·458	29·451	64·6	51·0	13	29·602	29·599	29·558	29·560	59·5	48·2
14	29·455	29·515	29·551	29·596	62·3	54·2	14	29·580	29·636	29·686	29·770	54·9	49·9
15	29·637	29·753	29·821	29·883	63·8	54·8	15	29·798	29·846	29·844	29·864	57·1	49·8
16	29·880	29·882	29·835	29·818	69·8	53·2	16	29·846	29·846	29·825	29·837	56·3	48·4
17	29·768	29·797	29·834	29·908	64·8	54·7	17	29·838	29·876	29·879	29·924	62·0	48·5
18	29·942	29·996	30·001	30·036	68·3	55·0	18	29·950	29·958	29·928	29·916	66·9	53·1
19	29·997	29·968	29·920	29·875	70·3	54·8	19	29·834	29·778	29·728	29·636	59·7	55·3
20	29·702	29·430	29·314	29·295	65·6	54·0	20	29·464	29·318	29·300	29·344	63·0	54·4
21	29·388	29·391	29·420	29·459	60·8	55·0	21	29·409	29·530	29·558	29·618	61·9	54·6
22	29·497	29·600	29·687	29·839	64·2	53·6	22	29·662	29·710	29·747	29·854	71·5	53·4
23	29·926	30·017	30·014	30·032	70·8	55·4	23	29·890	29·902	29·904	29·904	64·9	47·5
24	30·026	30·028	30·018	30·084	72·6	52·0	24	29·826	29·872	29·892	29·908	62·8	52·8
25	30·091	30·091	30·051	30·046	67·3	49·2	25	29·869	29·876	29·870	29·874	62·8	51·4
26	29·990	29·963	29·917	29·928	63·4	51·6	26	29·836	29·812	29·779	29·828	63·1	52·8
27	29·963	30·018	30·065	30·115	67·8	49·5	27	29·872	29·906	29·922	29·894	60·3	47·9
28	30·101	30·143	30·125	30·133	73·8	56·5	28	29·818	29·806	29·868	29·894	64·9	54·3
29	30·107	30·055	29·927	29·875	79·1	56·6	29	29·862	29·840	29·780	29·731	67·9	57·2
30	29·847	29·903	29·904	29·933	76·8	58·0	30	29·751	29·834	29·866	29·886	63·7	49·9
31	29·905	29·876	29·825	29·833	70·6	61·5	31	29·825	29·776	29·657	29·609	59·3	48·8

AUGUST, 1879.

1	29·801	29·827	29·910	30·057	73·3	57·4	1	29·568	29·673	29·812	29·936	61·0	51·0
2	30·107	30·102	30·042	30·057	68·8	52·0	2	30·007	30·078	30·080	30·093	63·7	47·7
3	29·884	29·824	29·832	29·888	72·8	55·0	3	30·037	29·961	29·895	29·864	59·9	46·2
4	29·880	29·924	29·983	30·019	68·8	58·2	4	29·777	29·726	29·762	29·783	60·0	51·8
5	29·965	29·892	29·751	29·709	66·2	53·2	5	29·714	29·706	29·620	29·558	62·2	52·7
6	29·698	29·725	29·755	29·806	64·3	52·0	6	29·424	29·416	29·431	29·503	58·9	52·0
7	29·807	29·834	29·848	29·848	65·8	53·0	7	29·508	29·559	29·616	29·680	61·5	50·2
8	29·812	29·821	29·817	29·794	64·8	55·5	8	29·699	29·724	29·738	29·770	58·3	45·9
9	29·797	29·901	29·933	29·974	67·7	51·7	9	29·784	29·838	29·844	29·897	62·2	45·9
10	29·976	29·999	29·972	29·988	72·8	47·8	10	29·916	29·924	29·908	29·928	62·8	42·4
11	29·969	29·971	29·951	29·955	72·6	57·8	11	29·904	29·907	29·888	29·896	68·1	52·8
12	29·922	29·917	29·859	29·841	72·9	56·5	12	29·845	29·812	29·754	29·733	71·2	60·0
13	29·809	29·791	29·806	29·861	75·2	55·6	13	29·611	29·662	29·679	29·753	68·1	55·9
14	29·925	30·001	30·008	30·017	74·0	59·0	14	29·856	29·950	30·010	30·030	64·9	50·8
15	29·946	29·918	29·825	29·816	75·3	59·2	15	29·980	29·897	29·792	29·762	66·2	45·0
16	29·696	29·621	29·567	29·535	68·7	55·0	16	29·698	29·688	29·587	29·526	60·2	51·2
17	29·444	29·487	29·577	29·612	56·8	52·0	17	29·426	29·422	29·438	29·535	62·1	52·1
18	29·596	29·648	29·637	29·717	69·0	52·2	18	29·571	29·600	29·623	29·650	63·2	51·3
19	29·749	29·799	29·787	29·788	64·3	51·0	19	29·638	29·688	29·664	29·636	61·0	53·7
20	29·656	29·644	29·648	29·705	66·6	56·6	20	29·520	29·452	29·414	29·492	63·0	53·6
21	29·708	29·626	29·569	29·612	70·8	58·6	21	29·504	29·492	29·452	29·366	63·8	52·5
22	29·628	29·668	29·726	29·822	68·5	56·0	22	29·270	29·260	29·294	29·458	59·8	51·7
23	29·816	29·771	29·708	29·766	64·8	55·8	23	29·548	29·630	29·683	29·756	62·8	51·8
24	29·871	29·983	29·947	29·914	70·5	53·4	24	29·796	29·844	29·802	29·680	63·1	52·2
25	29·781	29·753	29·757	29·748	67·7	56·0	25	29·418	29·382	29·298	29·202	60·0	49·5
26	29·658	29·622	29·688	29·767	60·8	53·2	26	29·226	29·334	29·296	29·470	62·1	49·5
27	29·754	29·601	29·454	29·481	63·4	53·5	27	29·412	29·220	29·020	29·132	58·5	52·1
28	29·521	29·502	29·473	29·543	65·0	55·8	28	29·136	29·094	28·962	29·722	62·7	50·9
29	29·598	29·725	29·796	29·883	64·8	55·8	29	29·070	29·300	29·455	29·636	59·8	48·0
30	29·923	29·964	29·912	29·928	66·0	49·8	30	29·695	29·717	29·649	29·644	57·9	45·1
31	29·938	30·037	30·123	30·268	63·3	49·0	31	29·649	29·784	29·980	30·116	56·8	43·8

BAROMETER READINGS, &c.

SEPTEMBER, 1879.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	30·354	30·438	30·409	30·445	63·8	41·5	1	30·194	30·257	30·237	30·173	59·1	43·4
2	30·415	30·410	30·303	30·352	68·1	41·5	2	30·032	29·964	29·919	29·936	56·0	50·1
3	30·238	30·189	30·070	30·074	70·3	46·5	3	29·856	29·810	29·760	29·868	56·9	50·3
4	30·053	30·086	30·078	30·086	68·0	44·0	4	29·970	30·077	30·074	30·074	58·8	44·8
5	30·024	29·986	29·907	29·874	63·6	54·0	5	30·028	29·992	29·980	29·807	57·0	41·5
6	29·786	29·756	29·684	29·680	67·8	55·4	6	29·684	29·650	29·585	29·548	61·4	52·9
7	29·615	29·583	29·505	29·641	66·0	50·5	7	29·486	29·407	29·275	29·246	64·3	55·0
8	29·678	29·663	29·581	29·552	64·9	48·6	8	29·256	29·325	29·272	29·194	60·9	50·9
9	29·464	29·526	29·578	29·724	62·8	53·0	9	29·178	29·326	29·469	29·643	61·1	48·5
10	29·829	29·941	29·986	30·040	62·8	47·6	10	29·748	29·834	29·849	29·828	58·0	47·3
11	30·008	29·966	29·888	29·823	62·8	50·9	11	29·719	29·647	29·520	29·382	56·2	51·0
12	29·719	29·676	29·633	29·633	62·8	57·0	12	29·356	29·322	29·270	29·389	57·0	45·8
13	29·655	29·713	29·667	29·641	67·2	53·6	13	29·452	29·553	29·610	29·672	58·3	45·9
14	29·649	29·793	29·850	29·961	63·8	50·2	14	29·660	29·699	29·740	29·810	58·0	44·8
15	29·953	29·991	29·924	29·965	64·2	45·2	15	29·832	29·886	29·900	29·956	56·6	51·0
16	29·932	29·943	29·932	29·939	64·1	51·0	16	29·968	29·996	29·989	29·998	57·0	50·1
17	29·894	29·912	29·881	29·891	63·8	56·8	17	29·948	29·958	29·913	29·927	57·4	50·7
18	29·878	29·920	29·940	29·987	64·0	56·4	18	29·906	29·949	29·954	30·010	57·3	46·9
19	30·025	30·103	30·108	30·132	65·8	54·5	19	30·053	30·110	30·078	30·018	57·6	46·9
20	30·106	30·083	30·014	30·034	66·9	53·9	20	29·874	29·766	29·708	29·738	57·9	48·5
21	30·013	30·024	29·936	29·836	62·0	50·9	21	29·778	29·781	29·634	29·532	53·6	47·4
22	29·821	29·887	29·878	29·827	60·8	47·4	22	29·559	29·677	29·654	29·419	54·9	46·2
23	29·613	29·526	29·496	29·429	62·0	51·2	23	28·978	29·101	29·193	29·290	54·9	44·2
24	29·266	29·489	29·559	29·679	58·8	48·2	24	29·334	29·414	29·492	29·622	54·2	41·1
25	29·916	30·112	30·171	30·256	59·4	41·4	25	29·700	29·770	29·827	29·902	51·5	40·2
26	30·277	30·296	30·256	30·275	62·2	41·0	26	29·867	30·006	30·097	30·091	56·3	40·7
27	30·257	30·291	30·238	30·232	60·7	46·8	27	30·194	30·155	29·997	29·828	55·3	36·2
28	30·150	30·121	30·033	30·012	61·8	49·0	28	29·716	29·730	29·813	29·898	55·0	42·1
29	29·990	30·072	30·109	30·160	58·7	52·2	29	29·904	29·973	30·033	30·095	55·7	41·1
30	30·133	30·117	30·068	29·989	62·9	50·9	30	30·082	30·066	29·946	29·768	55·1	40·1

OCTOBER, 1879.

1	29·785	29·650	29·755	29·865	64·1	50·6	1	29·576	29·450	29·517	29·589	56·0	42·8
2	29·880	29·833	29·890	29·986	57·6	46·9	2	29·569	29·551	29·542	29·665	50·9	42·0
3	30·070	30·152	30·130	30·163	58·8	41·8	3	29·698	29·696	29·672	29·790	51·9	44·6
4	30·156	30·214	30·207	30·236	64·8	50·7	4	29·894	30·032	30·080	30·128	58·0	46·4
5	30·236	30·264	30·246	30·282	61·8	45·4	5	30·130	30·172	30·204	30·244	58·8	44·3
6	30·279	30·333	30·302	30·333	63·8	52·6	6	30·268	30·303	30·287	30·321	58·9	40·6
7	30·338	30·388	30·374	30·431	62·8	48·0	7	30·335	30·381	30·391	30·450	55·0	42·5
8	30·444	30·478	30·456	30·495	56·3	45·6	8	30·469	30·509	30·479	30·476	49·1	43·3
9	30·474	30·474	30·413	30·414	53·1	42·8	9	30·447	30·425	30·403	30·406	55·3	40·6
10	30·396	30·444	30·410	30·456	56·4	37·2	10	30·382	30·401	30·382	30·394	56·1	40·7
11	30·465	30·515	30·465	30·500	56·5	40·0	11	30·409	30·446	30·424	30·465	55·6	39·8
12	30·495	30·535	30·491	30·475	49·7	42·2	12	30·456	30·470	30·424	30·391	50·2	41·2
13	30·420	30·399	30·304	30·271	50·7	44·0	13	30·324	30·302	30·209	30·158	51·1	46·9
14	30·205	30·175	30·048	30·080	53·8	44·0	14	30·072	30·085	30·163	30·266	52·7	34·5
15	30·121	30·154	30·114	30·179	47·9	37·8	15	30·261	30·257	30·230	30·264	45·4	31·9
16	30·170	30·211	30·184	30·166	48·8	33·8	16	30·244	30·206	30·036	29·761	49·7	32·6
17	30·014	29·834	29·760	29·805	56·4	34·3	17	29·564	29·629	29·722	29·836	53·0	37·3
18	29·861	29·962	29·934	29·852	51·3	42·7	18	29·855	29·866	29·718	29·502	52·3	33·4
19	29·662	29·608	29·500	29·439	60·1	48·2	19	29·222	29·158	29·128	29·019	54·5	42·1
20	29·354	29·350	29·421	29·621	55·1	44·5	20	28·986	29·200	29·346	29·618	50·9	37·0
21	29·731	29·850	29·883	29·961	51·7	40·0	21	29·696	29·779	29·815	29·826	49·1	35·8
22	29·956	29·943	29·900	29·971	54·3	38·0	22	29·704	29·706	29·792	29·856	55·0	45·3
23	29·977	30·028	29·978	29·955	57·1	51·8	23	29·836	29·822	29·769	29·638	57·5	50·3
24	29·852	29·817	29·711	29·641	59·1	53·6	24	29·541	29·570	29·540	29·329	55·1	41·9
25	29·637	29·732	29·778	29·884	55·0	36·8	25	29·526	29·579	29·639	29·815	47·9	36·9
26	29·945	30·006	29·993	30·020	53·3	32·5	26	29·949	30·080	30·109	30·206	46·8	32·9
27	30·033	30·095	30·126	30·196	56·6	44·5	27	30·211	30·255	30·243	30·283	47·3	34·8
28	30·200	30·239	30·192	30·178	52·9	47·7	28	30·272	30·270	30·202	30·237	46·1	29·7
29	30·149	30·165	30·134	30·156	49·1	46·0	29	30·217	30·246	30·280	30·339	52·0	41·9
30	30·164	30·209	30·179	30·200	53·4	48·0	30	30·342	30·382	30·366	30·377	45·7	43·8
31	30·159	30·180	30·124	30·105	49·3	46·0	31	30·332	30·304	30·226	30·162	44·4	38·9

BAROMETER READINGS, &c.

MARCH, 1879.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	29·832	29·979	30·050	30·150	46·4	35·0	1	29·883	29·978	29·950	29·825	42·0	29·9
2	30·158	30·168	30·074	30·036	47·9	25·7	2	29·726	29·768	29·518	29·580	44·7	39·0
3	29·940	29·884	29·893	30·012	45·7	30·7	3	29·436	29·500	29·672	29·626	40·4	33·1
4	30·075	30·082	30·054	30·055	47·9	32·5	4	29·562	29·468	29·440	29·502	48·1	36·2
5	30·030	30·031	29·952	29·934	52·2	44·2	5	29·482	29·406	29·445	29·476	50·1	40·8
6	30·059	30·192	30·209	30·318	53·7	35·8	6	29·706	29·952	29·898	30·043	46·4	38·0
7	30·399	30·503	30·514	30·565	55·0	32·0	7	30·195	30·344	30·410	30·476	49·7	39·8
8	30·588	30·575	30·473	30·456	56·8	29·1	8	30·468	30·412	30·310	30·250	50·9	36·6
9	30·404	30·446	30·383	30·425	59·8	29·4	9	30·140	30·150	30·150	30·140	48·8	42·2
10	30·408	30·410	30·291	30·234	54·9	36·1	10	30·100	30·084	29·996	30·051	47·1	37·8
11	30·156	30·319	30·340	30·342	48·3	43·0	11	30·146	30·138	30·198	30·122	44·3	33·1
12	30·208	30·051	29·903	30·101	54·7	37·2	12	29·758	29·632	29·991	30·218	49·7	30·7
13	30·261	30·358	30·300	30·276	43·3	30·3	13	30·259	30·258	30·260	30·258	39·0	24·3
14	30·225	30·209	30·081	29·969	39·8	32·0	14	30·220	30·168	29·985	29·790	31·7	21·3
15	29·850	29·798	29·667	29·641	49·9	39·1	15	29·548	29·493	29·458	29·521	33·7	27·7
16	29·618	29·688	29·746	29·876	53·9	42·9	16	29·600	29·726	29·842	29·972	37·1	30·1
17	29·987	30·080	30·059	30·043	45·7	36·0	17	30·009	30·032	29·918	29·835	36·6	30·5
18	29·941	29·874	29·758	29·710	51·9	37·5	18	29·783	29·765	29·680	29·647	39·3	33·8
19	29·674	29·715	29·679	29·732	63·7	41·2	19	29·650	29·744	29·802	29·900	43·6	36·0
20	29·726	29·785	29·733	29·816	54·1	42·1	20	29·922	29·955	29·954	29·974	39·2	36·8
21	29·796	29·834	29·775	29·741	44·9	38·7	21	29·932	29·921	29·863	29·924	45·3	34·6
22	29·690	29·745	29·745	29·780	39·1	35·2	22	29·990	30·066	30·054	30·078	37·7	31·9
23	29·780	29·820	29·815	29·852	37·5	33·0	23	30·082	30·132	30·127	30·144	39·0	32·8
24	29·837	29·855	29·824	29·834	33·8	30·5	24	30·112	30·118	30·089	30·124	35·0	31·6
25	29·799	29·799	29·740	29·711	33·7	29·7	25	30·075	30·023	29·920	29·896	34·9	31·5
26	29·671	29·652	29·611	29·598	35·9	32·4	26	29·832	29·840	29·818	29·822	36·9	28·6
27	29·545	29·547	29·523	29·567	40·9	33·0	27	29·776	29·770	29·742	29·748	36·1	26·9
28	29·594	29·682	29·714	29·729	44·4	31·6	28	29·700	29·666	29·521	29·348	39·0	28·4
29	trace.	29·643	29·659	29·782	57·1	38·2	29	29·350	29·358	29·450	29·457	51·1	35·4
30	lost.	29·727	29·656	29·652	52·9	38·4	30	29·333	29·255	29·266	29·295	50·5	39·0
31	29·602	29·610	29·591	29·622	53·5	43·0	31	29·289	29·339	29·325	29·338	48·8	37·8

APRIL, 1879.

1	29·617	29·665	29·604	29·623	51·9	42·0	1	29·328	29·472	29·500	29·560	51·1	39·0
2	29·606	29·610	29·545	29·544	53·9	37·5	2	29·538	29·526	29·490	29·522	49·5	34·9
3	29·521	29·556	29·568	29·646	52·9	33·0	3	29·517	29·534	29·514	29·544	48·9	30·9
4	29·710	29·794	29·783	29·845	54·7	34·0	4	29·555	29·596	29·594	29·606	49·0	37·5
5	29·823	29·794	29·708	29·647	54·3	41·2	5	29·548	29·462	29·364	29·300	50·1	44·3
6	29·575	29·435	29·276	29·187	51·4	42·5	6	29·208	29·156	28·974	28·946	49·8	41·6
7	28·949	28·918	28·962	28·989	59·2	45·2	7	29·020	29·024	28·928	29·000	47·0	38·9
8	29·054	29·207	29·288	29·382	57·4	45·0	8	29·076	29·120	29·226	29·381	48·0	40·8
9	29·399	29·406	29·446	29·511	53·4	42·0	9	29·461	29·586	29·671	29·794	40·9	38·7
10	29·555	29·674	29·806	29·958	47·4	35·5	10	29·882	30·002	30·062	30·173	43·8	35·5
11	29·999	30·081	30·052	30·075	41·3	31·0	11	30·162	30·184	30·104	30·074	48·1	35·0
12	30·004	29·913	29·762	29·653	42·2	28·4	12	29·973	29·940	29·877	29·813	42·0	31·7
13	29·583	29·620	29·604	29·626	46·9	33·0	13	29·760	29·794	29·820	29·852	39·3	30·3
14	29·552	29·519	29·488	29·511	44·4	34·2	14	29·770	29·732	29·663	29·680	40·6	32·9
15	29·472	29·483	29·442	29·481	57·2	35·2	15	29·636	29·629	29·572	29·573	42·7	35·4
16	29·456	29·504	29·511	29·569	45·4	38·0	16	29·515	29·504	29·450	29·502	49·5	30·9
17	29·567	29·616	29·646	29·761	49·0	34·4	17	29·540	29·653	29·706	29·824	45·1	34·5
18	29·827	29·876	29·880	29·919	46·5	33·2	18	29·866	29·919	29·878	29·885	47·0	30·7
19	29·909	29·869	29·731	29·624	52·9	30·9	19	29·830	29·780	29·646	29·610	50·5	31·8
20	29·440	29·363	29·341	29·379	54·9	38·1	20	29·522	29·490	29·466	29·508	42·1	37·4
21	29·392	29·433	29·478	29·555	44·9	39·2	21	29·508	29·562	29·566	29·602	49·0	34·8
22	29·548	29·557	29·520	29·505	50·7	33·7	22	29·558	29·520	29·507	29·498	43·7	38·4
23	29·443	29·424	29·424	29·499	54·1	41·5	23	29·460	29·474	29·492	29·593	46·9	37·4
24	29·567	29·751	29·922	30·071	53·9	44·0	24	29·668	29·828	29·958	30·030	44·7	38·7
25	30·090	30·063	29·948	29·775	56·9	35·0	25	29·972	29·866	29·696	29·592	45·7	36·1
26	29·710	29·688	29·617	29·582	60·1	42·0	26	29·556	29·545	29·532	29·596	53·6	40·4
27	29·567	29·618	29·634	29·780	59·0	43·0	27	29·674	29·762	29·846	29·949	45·2	41·7
28	29·843	29·927	30·011	30·146	52·1	40·0	28	30·012	30·122	30·186	30·253	49·9	39·1
29	30·223	30·288	30·286	30·271	51·5	35·4	29	30·248	30·252	30·238	30·246	51·3	38·1
30	30·207	30·203	30·167	30·143	50·5	40·0	30	30·210	30·216	30·164	30·184	47·8	37·0

BAROMETER READINGS, &c.

SEPTEMBER, 1879.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	30·354	30·438	30·409	30·445	63·8	41·5	1	30·194	30·257	30·237	30·173	59·1	43·4
2	30·415	30·410	30·303	30·352	68·1	41·5	2	30·032	29·964	29·919	29·936	56·0	50·1
3	30·238	30·189	30·070	30·074	70·3	46·5	3	29·856	29·810	29·760	29·868	56·9	50·3
4	30·053	30·086	30·078	30·086	68·0	44·0	4	29·970	30·077	30·074	30·074	58·8	44·8
5	30·024	29·986	29·907	29·874	63·6	54·0	5	30·028	29·992	29·980	29·807	57·0	41·5
6	29·786	29·756	29·684	29·680	67·8	55·4	6	29·684	29·650	29·585	29·548	61·4	52·9
7	29·615	29·583	29·505	29·641	66·0	50·5	7	29·486	29·407	29·275	29·246	64·3	55·0
8	29·678	29·663	29·581	29·552	64·9	48·6	8	29·256	29·325	29·272	29·194	60·9	50·9
9	29·464	29·526	29·578	29·724	62·8	53·0	9	29·178	29·326	29·469	29·643	61·1	48·5
10	29·829	29·941	29·986	30·040	62·8	47·6	10	29·748	29·834	29·849	29·828	58·0	47·3
11	30·008	29·966	29·888	29·823	62·8	50·9	11	29·719	29·647	29·520	29·382	56·2	51·0
12	29·719	29·676	29·633	29·633	62·8	57·0	12	29·356	29·322	29·270	29·329	57·0	45·8
13	29·655	29·713	29·667	29·641	67·2	53·6	13	29·452	29·553	29·610	29·672	58·3	45·9
14	29·649	29·703	29·850	29·961	63·8	50·2	14	29·660	29·699	29·740	29·810	58·0	44·8
15	29·953	29·991	29·924	29·965	64·2	45·2	15	29·832	29·886	29·900	29·956	56·6	51·0
16	29·932	29·943	29·932	29·939	64·1	51·0	16	29·968	29·996	29·989	29·998	57·0	50·1
17	29·894	29·912	29·881	29·891	63·8	56·8	17	29·948	29·958	29·913	29·927	57·4	50·7
18	29·878	29·920	29·940	29·987	64·0	56·4	18	29·906	29·949	29·954	30·010	57·3	46·9
19	30·025	30·103	30·108	30·132	65·8	54·5	19	30·053	30·110	30·078	30·018	57·6	46·9
20	30·106	30·083	30·014	30·034	66·9	53·9	20	29·874	29·766	29·708	29·738	57·9	48·5
21	30·013	30·024	29·936	29·836	62·0	50·9	21	29·778	29·781	29·634	29·532	53·6	47·4
22	29·821	29·887	29·878	29·827	60·8	47·4	22	29·559	29·677	29·654	29·419	54·9	46·2
23	29·613	29·526	29·496	29·429	62·0	51·2	23	28·978	29·101	29·193	29·290	54·9	44·2
24	29·266	29·489	29·559	29·679	58·8	48·2	24	29·334	29·414	29·492	29·622	54·2	41·1
25	29·916	30·112	30·171	30·256	59·4	41·4	25	29·700	29·770	29·827	29·902	51·5	40·2
26	30·277	30·296	30·256	30·275	62·2	41·0	26	29·867	30·006	30·097	30·091	56·3	40·7
27	30·257	30·291	30·238	30·232	60·7	46·8	27	30·194	30·155	29·997	29·828	55·3	36·2
28	30·150	30·121	30·033	30·012	61·8	49·0	28	29·716	29·730	29·813	29·898	55·0	42·1
29	29·990	30·072	30·109	30·160	58·7	52·2	29	29·904	29·973	30·033	30·095	55·7	41·1
30	30·133	30·117	30·068	29·989	62·9	50·9	30	30·082	30·066	29·946	29·768	55·1	40·1

OCTOBER, 1879.

1	29·785	29·650	29·755	29·865	64·1	50·6	1	29·576	29·450	29·517	29·589	56·0	42·8
2	29·880	29·833	29·890	29·986	57·6	46·9	2	29·569	29·551	29·542	29·663	50·9	42·0
3	30·070	30·152	30·130	30·163	58·8	41·8	3	29·698	29·696	29·672	29·790	51·9	44·6
4	30·156	30·214	30·207	30·236	64·8	50·7	4	29·894	30·032	30·080	30·128	58·0	46·4
5	30·226	30·264	30·246	30·282	61·8	45·4	5	30·130	30·172	30·204	30·244	58·8	44·3
6	30·279	30·333	30·302	30·333	63·8	52·6	6	30·268	30·303	30·287	30·321	58·9	40·6
7	30·338	30·388	30·374	30·431	62·8	48·0	7	30·335	30·381	30·391	30·450	55·0	42·5
8	30·444	30·478	30·456	30·495	56·3	45·6	8	30·469	30·509	30·479	30·476	49·1	43·3
9	30·474	30·474	30·413	30·414	53·1	42·8	9	30·447	30·425	30·403	30·406	55·3	40·6
10	30·396	30·444	30·410	30·456	56·4	37·2	10	30·382	30·401	30·382	30·394	56·1	40·7
11	30·465	30·515	30·465	30·500	56·5	40·0	11	30·409	30·446	30·424	30·465	55·6	39·8
12	30·495	30·535	30·491	30·475	49·7	42·2	12	30·456	30·470	30·424	30·391	50·2	41·2
13	30·420	30·399	30·304	30·271	50·7	44·0	13	30·324	30·302	30·209	30·158	51·1	46·9
14	30·205	30·175	30·048	30·080	53·8	44·0	14	30·072	30·085	30·163	30·266	52·7	34·5
15	30·121	30·154	30·114	30·179	47·9	37·8	15	30·261	30·257	30·230	30·264	45·4	31·9
16	30·170	30·211	30·184	30·166	48·8	33·8	16	30·244	30·206	30·036	29·761	49·7	32·0
17	30·014	29·834	29·760	29·805	56·4	34·3	17	29·564	29·629	29·722	29·836	52·0	37·3
18	29·861	29·962	29·934	29·852	51·3	42·7	18	29·855	29·866	29·718	29·502	52·3	33·4
19	29·662	29·608	29·500	29·439	60·1	48·2	19	29·222	29·158	29·128	29·019	54·5	42·1
20	29·354	29·350	29·421	29·621	55·1	44·5	20	28·986	29·200	29·346	29·618	50·9	37·0
21	29·731	29·850	29·883	29·961	51·7	40·0	21	29·696	29·779	29·815	29·826	49·1	35·8
22	29·956	29·943	29·900	29·971	54·3	38·0	22	29·704	29·706	29·792	29·856	55·0	45·3
23	29·977	30·028	29·978	29·955	57·1	51·8	23	29·836	29·822	29·769	29·658	57·5	50·3
24	29·852	29·817	29·711	29·641	59·1	53·6	24	29·541	29·570	29·540	29·329	55·1	41·9
25	29·637	29·732	29·778	29·884	55·0	36·8	25	29·526	29·579	29·639	29·815	47·9	36·9
26	29·945	30·006	29·993	30·020	53·3	32·5	26	29·949	30·080	30·109	30·206	46·8	32·9
27	30·033	30·095	30·126	30·196	56·6	44·5	27	30·211	30·255	30·243	30·283	47·3	34·8
28	30·200	30·239	30·192	30·178	52·9	47·7	28	30·272	30·270	30·202	30·237	46·1	39·7
29	30·149	30·165	30·134	30·156	49·1	46·0	29	30·217	30·246	30·280	30·339	52·0	41·9
30	30·164	30·209	30·179	30·200	53·4	48·0	30	30·342	30·382	30·366	30·377	45·7	43·5
31	30·159	30·180	30·124	30·105	49·3	46·0	31	30·332	30·304	30·226	30·162	44·4	38·9

BAROMETER READINGS, &c.

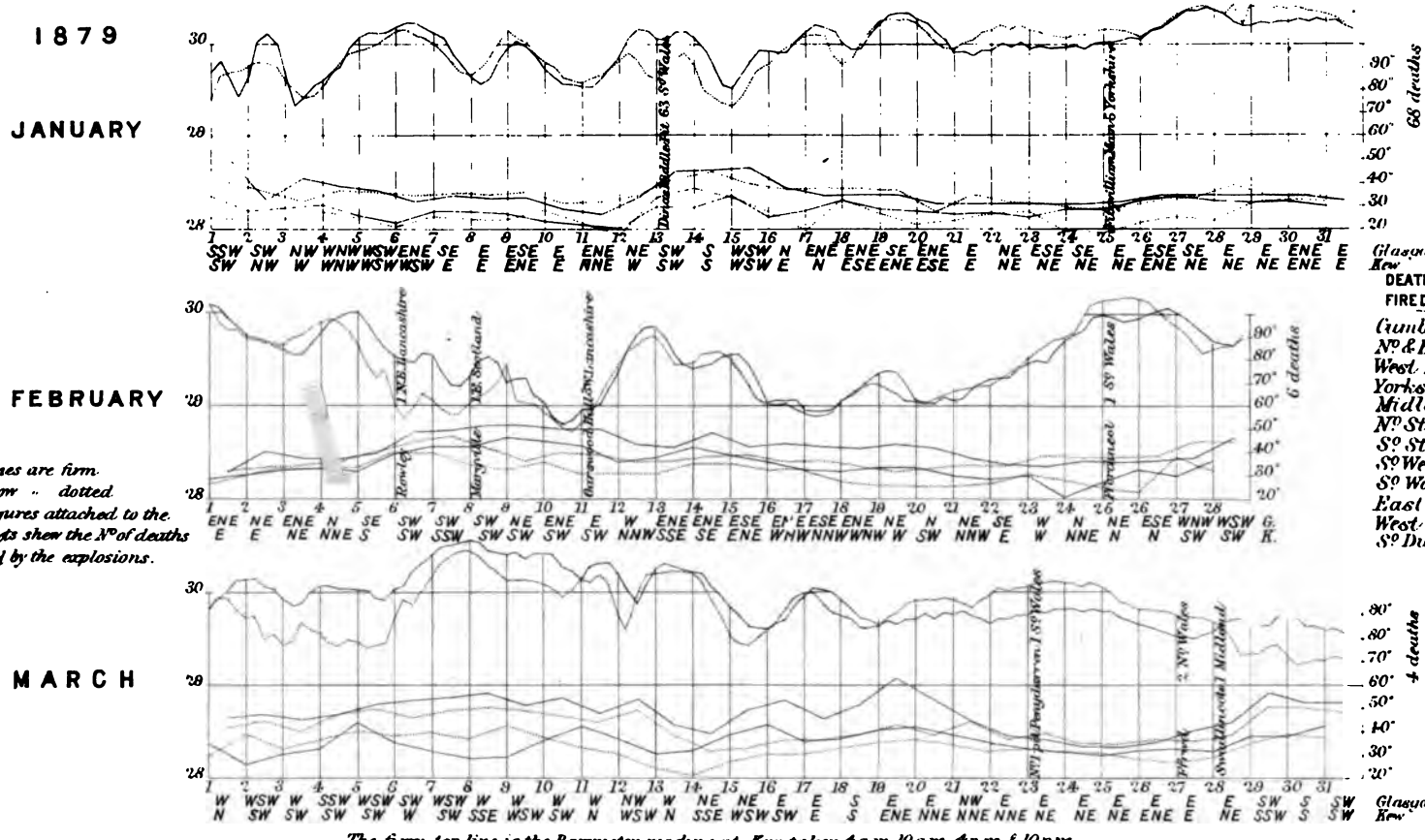
NOVEMBER, 1879.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	30·045	30·039	29·976	30·068	47·1	38·5	1	30·063	30·155	30·218	30·297	43·3	33·9
2	30·105	30·163	30·188	30·268	43·9	33·2	2	30·324	30·372	30·349	30·386	45·7	36·5
3	30·299	30·358	30·365	30·451	46·8	36·1	3	30·413	30·463	30·427	30·450	49·5	35·6
4	30·479	30·524	30·520	30·518	47·5	44·3	4	30·442	30·476	30·427	30·362	45·0	27·0
5	30·490	30·489	30·468	30·525	50·9	39·0	5	30·269	30·332	30·324	30·358	49·2	41·1
6	30·500	30·505	30·435	30·478	50·4	36·7	6	30·329	30·330	30·356	30·393	51·0	45·5
7	30·489	30·562	30·564	30·583	53·3	36·8	7	30·428	30·486	30·462	30·479	52·7	45·3
8	30·568	30·561	30·507	30·485	48·1	35·8	8	30·426	30·407	30·330	30·246	47·6	45·1
9	30·411	30·391	30·296	30·227	50·6	44·8	9	30·110	30·057	29·999	30·014	49·8	43·9
10	30·133	30·114	30·139	30·214	51·1	44·5	10	30·085	30·162	30·140	30·076	45·9	35·2
11	30·182	30·098	29·855	29·758	46·9	42·0	11	29·878	29·608	29·450	29·434	44·1	40·7
12	29·724	29·851	29·953	30·016	46·9	38·2	12	29·664	29·884	29·944	30·010	43·5	34·0
13	30·040	30·105	30·161	30·248	45·5	34·5	13	30·100	30·206	30·214	30·254	41·3	30·0
14	30·256	30·299	30·288	30·356	42·3	27·6	14	30·256	30·301	30·274	30·313	36·9	25·7
15	30·372	30·425	30·407	30·454	35·1	24·3	15	30·302	30·307	30·287	30·262	42·0	34·0
16	30·446	30·416	30·363	30·320	38·5	21·8	16	30·220	30·189	30·107	30·082	47·3	41·4
17	30·273	30·268	30·178	30·151	50·7	38·8	17	29·999	29·894	29·895	30·041	53·8	46·7
18	30·149	30·240	30·258	30·316	55·4	41·2	18	30·105	30·207	30·272	30·364	55·3	45·1
19	30·312	30·303	30·267	30·252	45·7	37·4	19	30·378	30·407	30·386	30·404	52·0	44·6
20	30·177	30·100	30·001	29·920	40·6	32·0	20	30·396	30·392	30·335	30·349	45·3	38·3
21	29·809	29·799	29·795	29·789	35·1	32·2	21	30·254	30·106	29·977	29·927	44·2	41·0
22	29·892	29·953	29·968	29·987	34·8	29·9	22	29·815	29·816	29·874	29·913	43·9	37·3
23	30·012	30·031	29·963	29·959	34·1	25·7	23	29·857	29·931	29·997	30·064	43·7	35·0
24	29·956	30·053	30·063	30·109	37·4	31·3	24	30·080	30·162	30·208	30·307	42·2	34·7
25	30·142	30·202	30·182	30·204	40·1	33·5	25	30·367	30·437	30·428	30·438	38·2	34·9
26	30·175	30·172	30·084	30·085	36·3	32·9	26	30·388	30·339	30·271	30·256	38·7	33·1
27	30·057	30·076	30·057	30·130	40·0	31·1	27	30·257	30·316	30·310	30·316	41·1	36·3
28	30·116	30·085	30·012	29·971	41·5	29·5	28	30·225	30·154	30·056	30·063	46·1	27·7
29	29·943	29·952	29·918	29·932	38·9	30·1	29	30·056	30·068	30·030	30·002	37·7	30·9
30	29·880	29·834	29·774	29·769	34·6	26·3	30	29·936	29·894	29·855	29·884	35·0	27·3

DECEMBER, 1879.

1	29·730	29·688	29·720	29·846	34·0	24·4	1	29·892	29·900	29·850	29·858	36·0	28·6
2	29·901	29·939	29·889	29·883	31·7	18·0	2	29·844	29·848	29·818	29·857	35·2	26·9
3	29·859	29·842	29·747	29·697	30·0	17·8	3	29·864	29·884	29·827	29·804	34·1	23·7
4	29·620	29·559	29·491	29·484	31·9	23·4	4	29·750	29·742	29·642	29·559	27·5	16·4
5	29·552	29·713	29·653	29·565	32·7	22·5	5	29·487	29·457	29·449	29·606	26·0	13·5
6	29·695	29·980	30·157	30·326	30·3	20·8	6	29·771	29·963	30·069	30·200	35·9	25·9
7	30·415	30·488	30·470	30·469	29·4	13·0	7	30·255	30·324	30·351	30·406	37·4	25·9
8	30·416	30·464	30·484	30·550	37·8	29·0	8	30·428	30·456	30·437	30·421	37·3	28·9
9	30·585	30·586	30·521	30·478	34·4	25·9	9	30·354	30·293	30·270	30·381	41·9	32·9
10	30·407	30·440	30·465	30·523	38·2	28·6	10	30·434	30·478	30·464	30·468	35·7	25·7
11	30·548	30·598	30·567	30·596	32·5	19·3	11	30·436	30·467	30·466	30·518	34·3	23·5
12	30·598	30·654	30·669	30·682	36·3	30·0	12	30·537	30·588	30·590	30·609	37·8	23·3
13	30·711	30·751	30·693	30·654	36·6	30·9	13	30·587	30·555	30·447	30·369	40·9	36·8
14	30·583	30·548	30·496	30·470	32·9	31·8	14	30·260	30·224	30·188	30·226	44·8	39·9
15	30·431	30·442	30·419	30·446	42·6	37·0	15	30·242	30·306	30·321	30·337	46·9	40·8
16	30·436	30·479	30·453	30·483	38·4	26·4	16	30·304	30·280	30·218	30·247	45·8	41·8
17	30·520	30·576	30·576	30·596	28·7	21·3	17	30·319	30·426	30·494	30·562	46·7	39·3
18	30·565	30·583	30·564	30·583	38·3	23·8	18	30·558	30·591	30·578	30·590	40·6	34·7
19	30·578	30·604	30·578	30·573	35·0	31·0	19	30·578	30·613	30·592	30·565	37·2	33·0
20	30·500	30·497	30·440	30·412	35·6	29·7	20	30·511	30·466	30·359	30·288	35·6	30·9
21	30·362	30·379	30·323	30·319	31·7	26·5	21	30·196	30·125	29·965	29·859	44·9	33·6
22	30·309	30·469	30·631	30·747	43·6	27·7	22	30·024	30·259	30·304	30·294	45·9	37·7
23	30·777	30·778	30·661	30·561	36·6	26·1	23	30·367	30·408	30·287	30·183	49·3	44·4
24	30·416	30·419	30·390	30·463	39·4	23·8	24	29·958	30·044	30·087	30·088	44·4	38·6
25	30·511	30·577	30·558	30·560	38·5	26·3	25	30·324	30·404	30·404	30·390	42·0	34·8
26	30·518	30·488	30·450	30·447	33·5	29·0	26	30·300	30·273	30·214	30·265	40·6	36·8
27	30·423	30·432	30·324	30·207	38·9	26·7	27	30·026	29·883	29·618	29·400	50·7	36·3
28	30·124	30·089	29·992	29·922	52·1	34·5	28	29·536	29·666	29·190	29·345	53·3	42·7
29	29·961	29·989	29·847	29·948	53·2	40·5	29	29·477	29·492	29·396	29·462	43·7	35·3
30	29·998	29·740	29·597	29·743	44·5	37·6	30	29·458	29·108	29·109	29·366	40·8	33·8
31	29·862	29·726	29·646	29·733	53·9	36·2	31	29·374	29·209	29·250	29·262	49·0	33·7

DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.



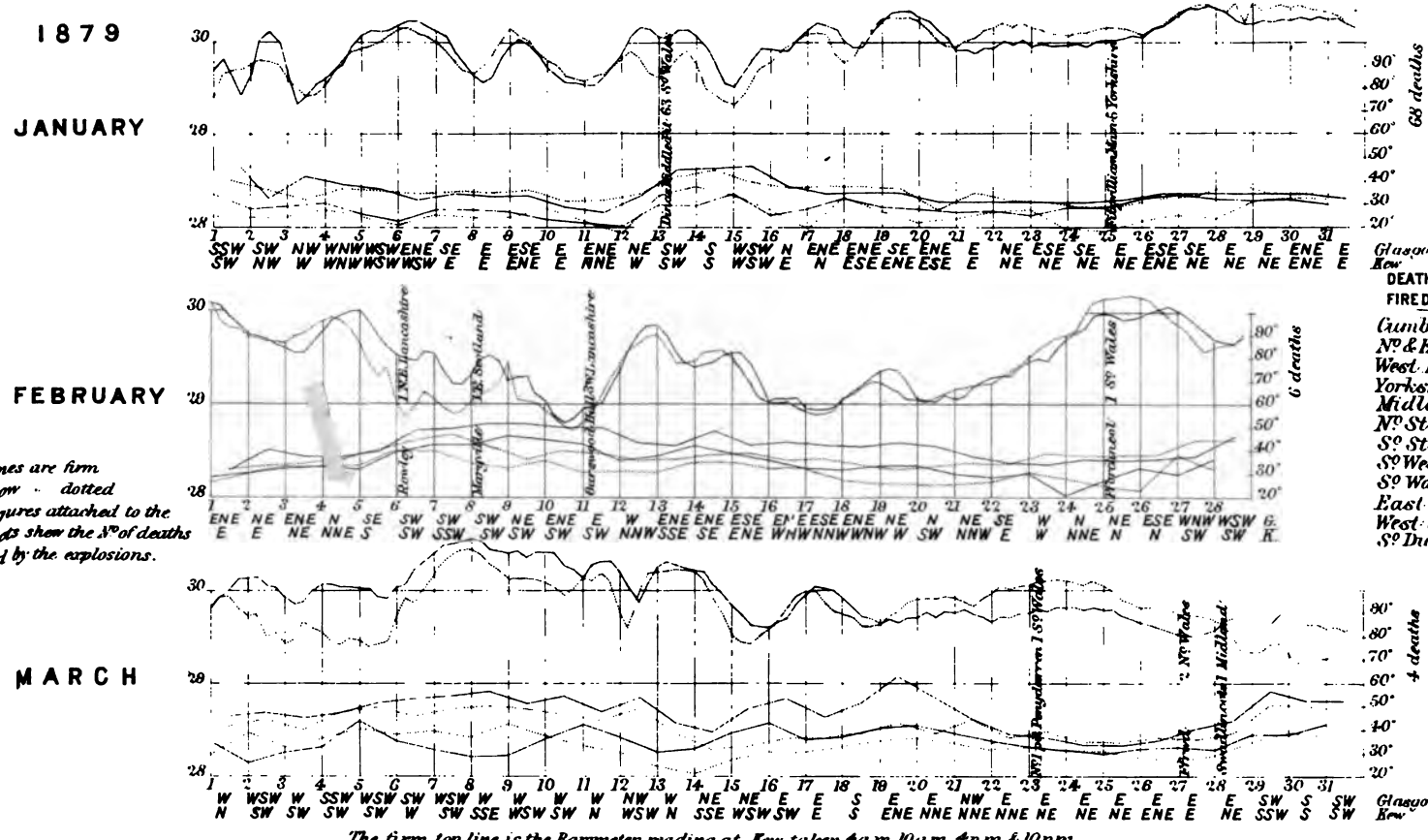
DEATHS FROM EXPLOSIONS OF FIREDAMP DURING THE YEAR 1879

Cumberland	14
Nº & E. Lancashire	10
West Lancashire & Nº Wales	5
Yorkshire	31
Midland	1
Nº Staffordshire &c	10
Sº Staffordshire &c	10
Sº Western Monmouth &c	9
Sº Wales	70
East of Scotland	32
West of Scotland	5
Sº Durham	0
	184

lines are firm.
sgow " dotted
figures attached to the
tricts shew the Nº of deaths
sed by the explosions.

The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m. & 10 p.m.
The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 a.m. & 10 p.m.

WIND AT THE OBSERVATORIES of KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.



lines are firm
sgow - dotted
figures attached to the
ricts shew the No of deaths
sed by the explosions.

DEATHS FROM EXPLOSIONS OF FIREDAMP DURING THE YEAR 1879

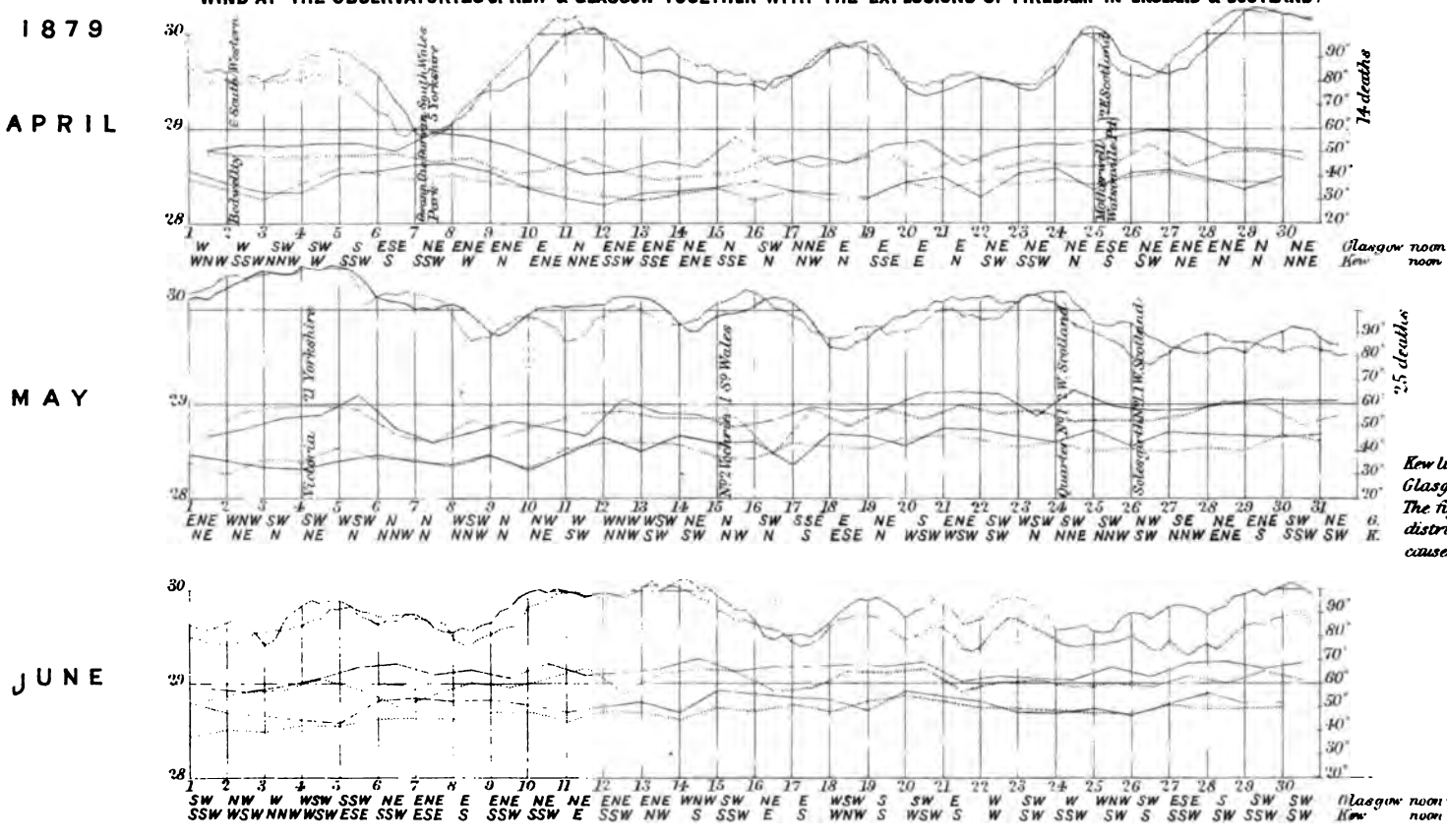
Cumberland	1 d
No & E. Lancashire	10
West Lancashire & No Wales	5
Yorkshire	31
Midland	1
No Staffordshire &c	10
So Staffordshire &c	10
So Western Monmouth &c	9
So Wales	70
East of Scotland	32
West of Scotland	5
So Durham	0
	184

The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m. & 10 p.m.
The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 a.m. & 10 p.m.

proceedings No E.I of M&ME 1879-80

Ald^n Rud Newcastle

DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.



Kew lines are firm
Glasgow - dotted
The figures attached to the districts shew the No of deaths caused by the explosions.

The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m. & 10 p.m.
The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 a.m. & 10 p.m.

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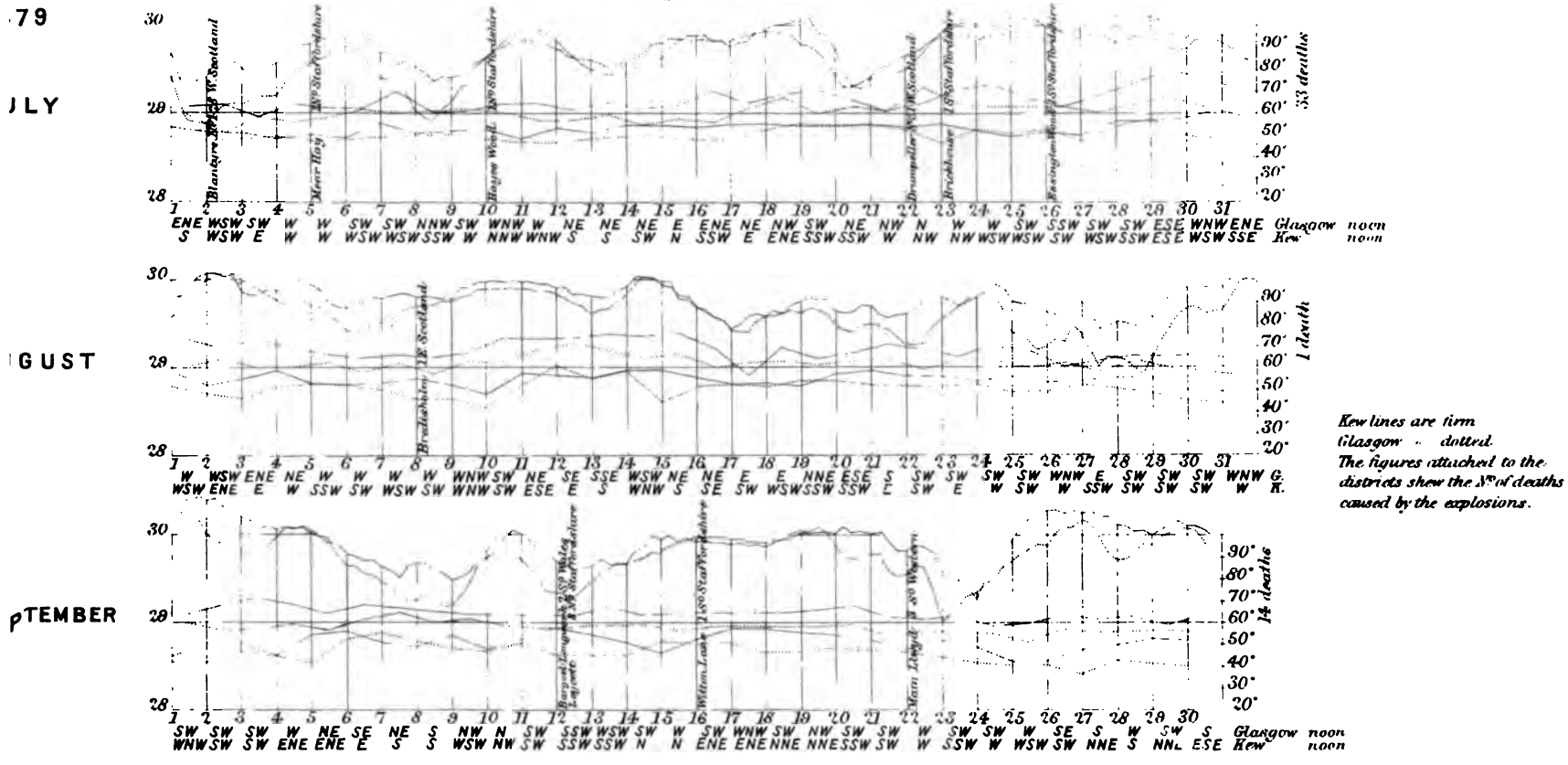

The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m. & 10 p.m.
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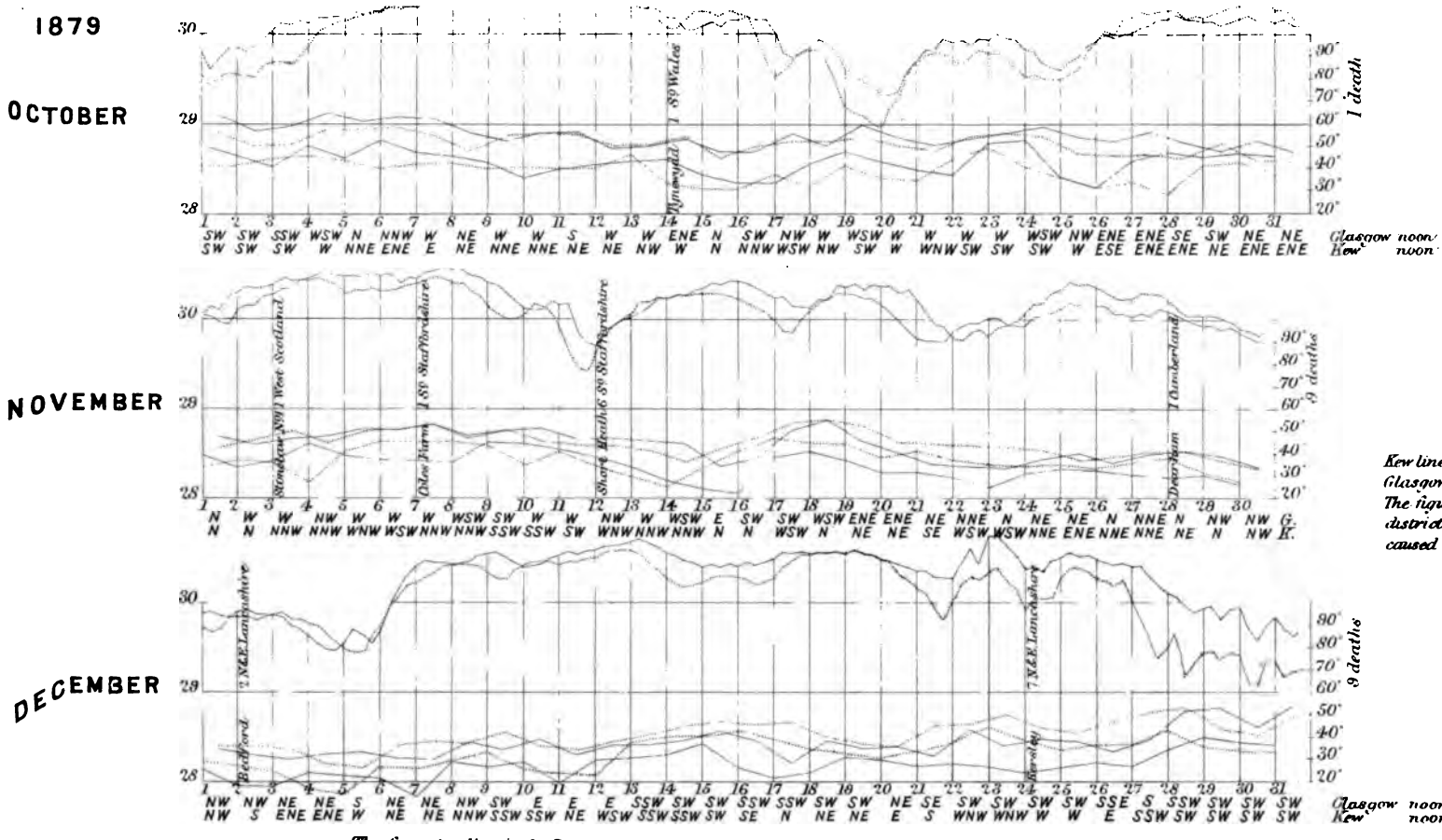
And. Reid New 1881



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The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 a.m. & 10 p.m.

And^w Reid Newcastle

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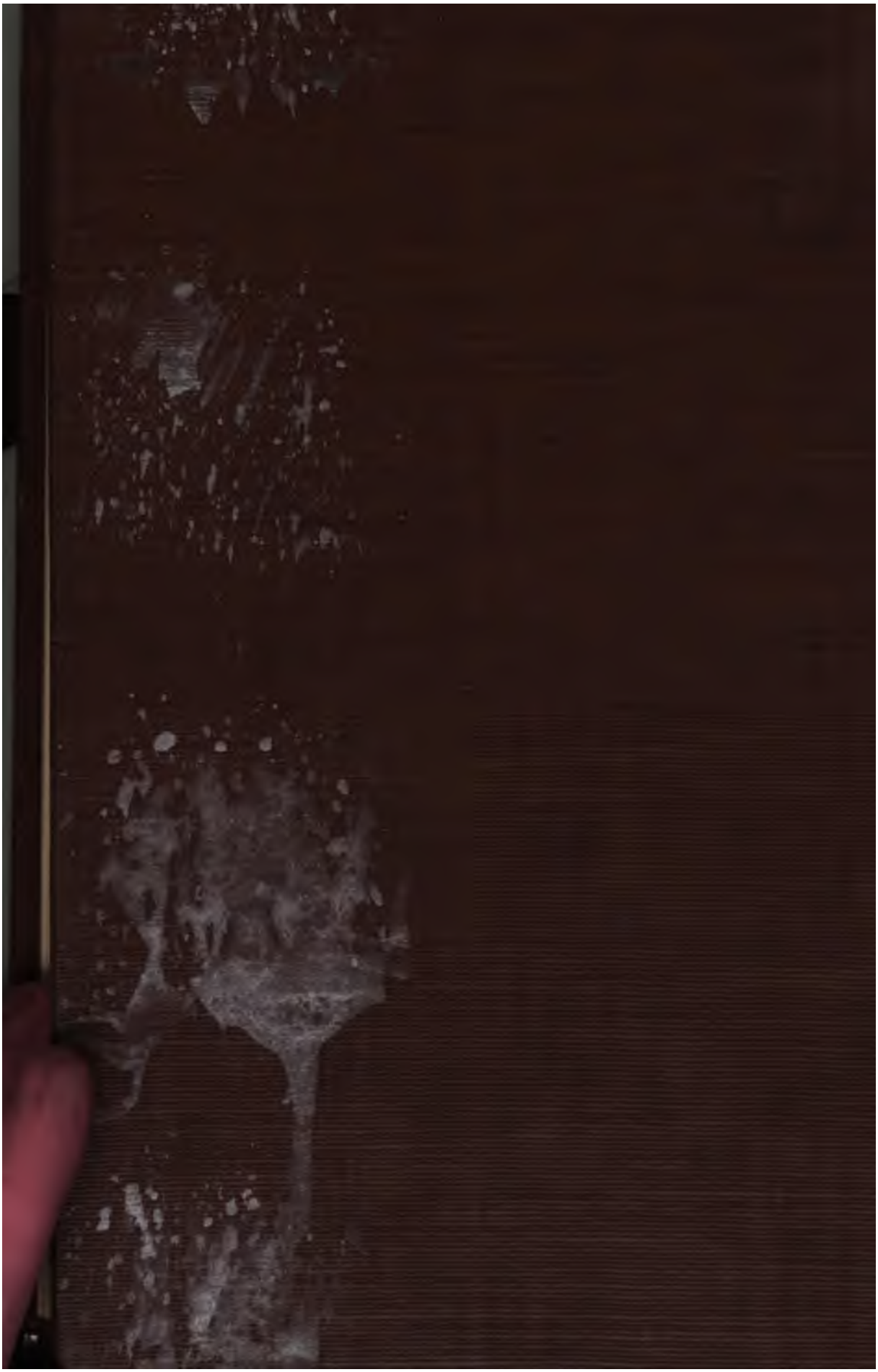
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